POWER PLANT ENGINEERING

Established Over 31 Years

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Contents of this Issue

Page

Northern New Jersey Profits by New Whippany Plant. By J. E. Shoudy. Illustrated....812

Extraction Heaters Increase Cycle Efficiency. By K. S. Kramer. Illustrated....817

Centrifugal Action Purifies Oil. By Henry Moore. Illustrated....819

Glass Plant Has Varied Power Demands. Illustrated....822

Many Factors Govern Slagging of Furnace....823

Steam Accumulators for Industrial Plants....824

Investigation Reveals Principles of Boiler Scale Formation.824

Use of Reclosing Equipment on A. C. Lines. By A. E. Anderson. Illustrated....825

Features of the Super-Synchronous Motor. Illustrated....828

McGregor Plant of Colorado Utilities Corp. Illustrated...830

Power Consumption of Flour Mills. By Grover C. Meyer. Illustrated....831

Results of Efficiency Tests at Wilson Dam. By L. B. Feagin. Illustrated....832

Where One Boiler Serves Entire Textile Plant. Illustrated....836

Improvements in Ammonia Compressors and Valves....838

Operation of the Holtwood Steam Station. By F. A. Allner. Illustrated....839

Instrument Selection Should Receive Attention. Illustrated.841

Early Steam Boiler Evolution...By David Brownlie. Illustrated....843

U. S. Water Power Development in 1926....845

Commercial Efficiency Should Be Considered. Illustrated..846

Letters Direct from the Plant: Three to Two Phase Transformations. Comment on European Supremacy. Durable Gasket Cutters. Simple Device Avoids Equipment Expenditure. Flexible Joint Allows Misalinement. Placing Pulleys for Quarter Turn Belts. Folding Construction Makes Horse More Convenient. Illustrated...847

Questions and Answers: Valve Motion and Governor Problems. Relation Between Coal Consumption and Developed Horsepower. Problems in Steam Engineering. Illustrated....850

Editorial Comment: Passing the Buck in Engineering Education. Impending Changes in Our Use of Fuels. To the Solid Ground of Nature....852

American Blower Air Filter. Illustrated....854

Pliers Type Current Measuring Set. Illustrated....854

Westinghouse Develops Single Retort Underfeed Stoker. Illustrated....855

Adamant Gun for Applying Refractories. Illustrated....856

New S-A Gear Division Brings Out Speeducer. Illustrated.856

Vibro Damper to Deaden Machine Vibrations. Illustrated.856

New Features of Nicholson Coupling. Illustrated....857

University of Iowa Builds New Power Plant. Illustrated..857

News Notes....858

Books and Catalogs....859

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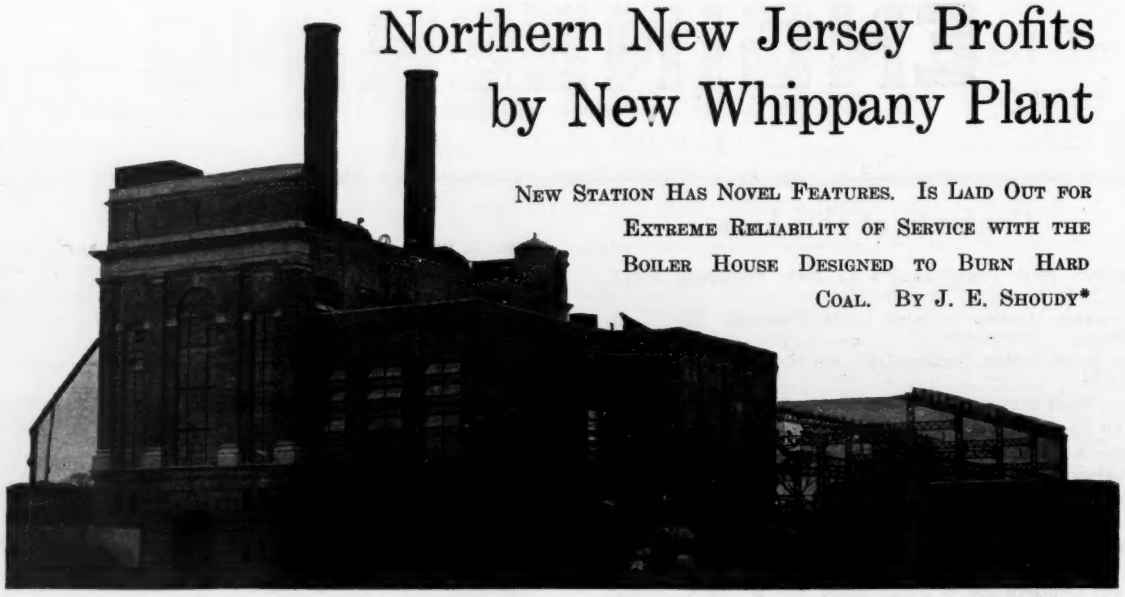
Ahkla Learns How Light Is Made

JIM AHKLA, a reindeer herder from Consul, Alaska, 90 miles northeast of Nome, where nights are six months long, visits the General Electric Plant in Schenectady and is shown a giant 50,000-kw. steam turbine destined for Buenos Ayres, which is capable of taking up the task after the sun has laid down on the job of producing enough electricity to illuminate every igloo in all Alaska.

How light is made by machinery is being explained by William Madigan, the shop foreman of the General Electric turbine department. From appearances we may readily judge that much of the light Mr. Madigan is throwing on the subject is going over Jim's head rather than through it. Jim more likely is wondering if the turbinus vaporus elephantus contraption before him has anything to do with the making of Eskimo pies.

Despite the moderate temperature, Jim insisted upon wearing his fur parkee, saying "What keeps out cold, keeps out heat," thus demonstrating that he is willing to suffer for a cause as readily as does the modern flapper who wears furs in summer and in winter bares her chest to the elements.

Northern New Jersey Profits by New Whippany Plant



NEW STATION HAS NOVEL FEATURES. IS LAID OUT FOR EXTREME RELIABILITY OF SERVICE WITH THE BOILER HOUSE DESIGNED TO BURN HARD COAL. BY J. E. SHOUDY*

COMPLETION of the 20,000-kw. Whippany Steam Power Station has brought to the Jersey Central Power & Light Co., a subsidiary of the National Public Service Co., the sufficient and economical power that is required to supply the expanding service of the company in Northern New Jersey.

The plant, a product of the General Engineering & Management Corporation, has been designed to meet the particular conditions which called for reliability of service, economical production and an attractive appearance to fit into the rich suburban community which it supplies. The territory is largely residential for a commuting population whose business interests lie in New York City and the large cities of northeastern New Jersey. Because of the nearness to the large centers of population most of the available water has already been appropriated to supply city needs. To secure a suitable location, therefore, required a very careful investigation.

Finally a site was selected about 2 mi. north of the village of Whippany. It is but 6 mi. distant from both Morristown and Summit where the earlier power plants of the company are located. Selection was dictated in part by the fact that it furnishes rail connection to the anthracite fields of Pennsylvania over either the Lackawanna or Erie systems through the Morristown and Erie Railroad, a connecting link between them. The other determining factor was that Whippany Creek, which passes through the property, offers the best water supply for cooling purposes still available in that section of the state.

Steel and brick construction with steel sash and doors was used. The plant, covering an area of 112 by 140 ft., consists of a boiler room, a turbine room and an electrical bay, all under one roof but separated by brick partitions. Measured from center to center of the corner steel columns the boiler room is 140 by 62 by 87 ft. high, except a longitudinal strip over the bunkers 140 ft. long and 20 ft. wide which rises 101 ft. above the basement floor; the turbine room is 140 by 51 by 64 ft. high, and the electrical bay is 68 by 21 by 64 ft. high.

All building columns and walls are supported on reinforced concrete foundations. The maximum depth to which these were carried was 7 ft. At this depth a very firm bed of hardpan was encountered, underlaid by a strata of loose gravel. To obviate cutting through this hardpan and sinking the foundations a very great depth, a system of continuous footings for rows of columns was adopted. All floors are of reenforced concrete using deformed bars for reenforcement, and with the exception of those of the turbine room and the control room, the floors are overlaid with a 1-in. wearing course of cement and sand to produce a smooth floor. The turbines are installed on a semi-island principle on foundations raised 25 ft. above the main floor and surrounded by a platform cantilevered from the turbine foundation and joining a floor at the turbine elevation. A walkway to the electrical bay separates two large hatches on the west which facilitate the handling of machinery and furnish abundant light to the floor below. The interior includes a suitable office on the main floor, a laboratory, a machine shop and locker and toilet facilities for the force.

ARCHITECTURAL TREATMENT GIVEN SERIOUS CONSIDERATION

The question of an attractive exterior was solved by careful design rather than by the use of expensive material. Hobart Upjohn, consulting architect, accomplished some exceptional results by studying the plan in bulk and setting this mass off in the most artistic manner. As a result, it was possible to use the cheapest common red brick on the exterior. On three sides of the boiler room the long windows are capped with circular window heads and between them are flat columns of brick set off with terra cotta bases and caps along Doric lines. Terra cotta water table, cornice and facing

*General Eng. & Management Corp., New York.

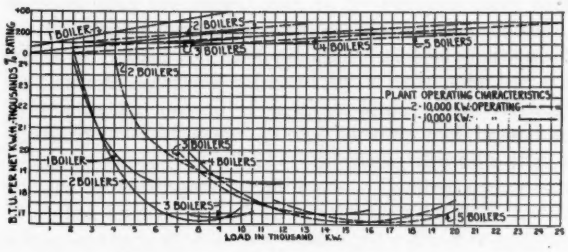


FIG. 1. AT THE MOST ECONOMICAL LOAD A KW. WILL BE GENERATED WITH ABOUT 16,500 B.T.U.

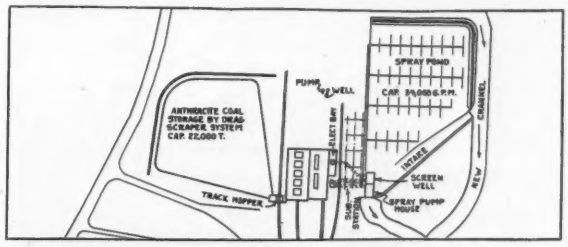


FIG. 2. A NEW RIVER CHANNEL WAS CUT AND THE OLD CHANNEL UTILIZED AS AN INTAKE

from cornice coping add much to the appearance. The terra cotta is finished to imitate unglazed lime stone. Thus an exceedingly satisfactory result has been secured at an expense considerably less than could have been secured by the use of more expensive material without the care in design.

Turbine room floors are finished with a layer of red quarry tile and a base cover to match. The walls are finished with salt face glazed brick panelled around the window openings. Where no windows occur as in the wall separating the turbine and boiler rooms reveals the same size as the windows are made of buff salt face glazed brick. Around the panels a mottled brown face brick is used with smooth pale gray face brick above all the windows and reveals. Dark green terra cotta diamond shape inserts are placed at the corners of the face brick panels.

Anthracite of the smallest and cheapest form, No. 3 Buckwheat, is the fuel to be used. This is handled from car to furnace by efficient machinery, designed to operate at an initial capacity of 60 t. per hr. Coal is discharged from the cars through a concrete track hopper to the pan of a shaking feeder from which it is discharged through a chute to the receiving hopper of a vertical belt elevator. The elevator delivers it to the inclined tail end of a bunker conveyor equipped with an automatic tripper discharging to the bunker below. This is a catenary section cast iron bunker approximately 136 ft. long with a capacity of 6.5 t. per lineal ft. If not needed in the bunker the coal may be discharged through a chute from the elevator which carries it to the coal storage where it is stored and reclaimed by a drag scraper. A series of double cutoff gates have been provided for drawing the coal from the bunker to a motor driven weigh larry and from there direct to the stoker hoppers. Yard storage space has been provided for 30,000 t.

Ashes are dropped from the furnace directly into an ash hopper of 560 cu. ft. capacity. From this, by means of auxiliary oil operated gates, the ashes may be dropped into standard railway cars for removal or into a truck if the ashes are needed for local fill or other use.

Fuel Burned Will Be Small Sized Anthracite

Furnaces are designed for burning the smaller sizes of anthracite and are in many ways similar to those developed for the Amsterdam station of the Adirondack Power & Light Corp. The main point of difference is that the Whippany furnaces are provided with a slightly longer rear arch. The setting walls are of the Detrick suspended type up to the line of the bottom row of tubes and above this line are standard construction. Refractory is supported by special castings which in turn are hung from Z bars bolted to a sheet steel casing, thus giving an air space between the refractory and the casing. Holes drilled at the bottom and top of this casing give a natural air ventilation and cooling of the refractory. No attempt has been made to collect the warm air from these walls. The quantity of air required has not yet been determined and it is thought that this quantity will be so small that the cost of connecting into the combustion system will not be justified.

Air for combustion is drawn down through air heaters to the induced draft fan and thence to the stokers. The air intake passes through the roof; a damper in the duct near the roof permits taking some of the combustion air from the hottest part of the boiler room, thus conserving the heat of the boiler room, or all may be drawn direct from above the roof.

So as to avoid the necessity of purchasing a special type of stoker, designed for high temperature air, the standard type of stoker was purchased and the temperature of combustion air limited to about 250 deg. Experience has shown that this slight preheat has a marked effect upon combustion efficiency. It was consequently decided to use both economizers and air heaters.

Duplicate Equipment Insures Reliability

Reliability has been the keynote of the entire design of the mechanical and electrical equipment. Hence the slight additional economy of a larger turbine has been sacrificed by the installation of two 10,000-kw. turbines. These are Allis-Chalmers 3-phase, 60-cycle, 1800-r.p.m., to operate at 6600 v., with 250-v. direct connected exciters. This principle of duplication of equipment has been followed wherever economically possible.

Steam is generated in five Springfield boilers, having a heating surface of 9160 sq. ft. per boiler and consisting of 13 sections each containing 11 groups of 4-in. tubes. The tubes are designed for a pressure of 320 lb. and the drums for 325 lb. Each boiler is equipped with separate forced draft and induced draft fans operated

FIG. 3. FIVE 916-HP. STOKER FIRED BOILERS FURNISH STEAM FOR TWO 10,000-KW. TURBINES

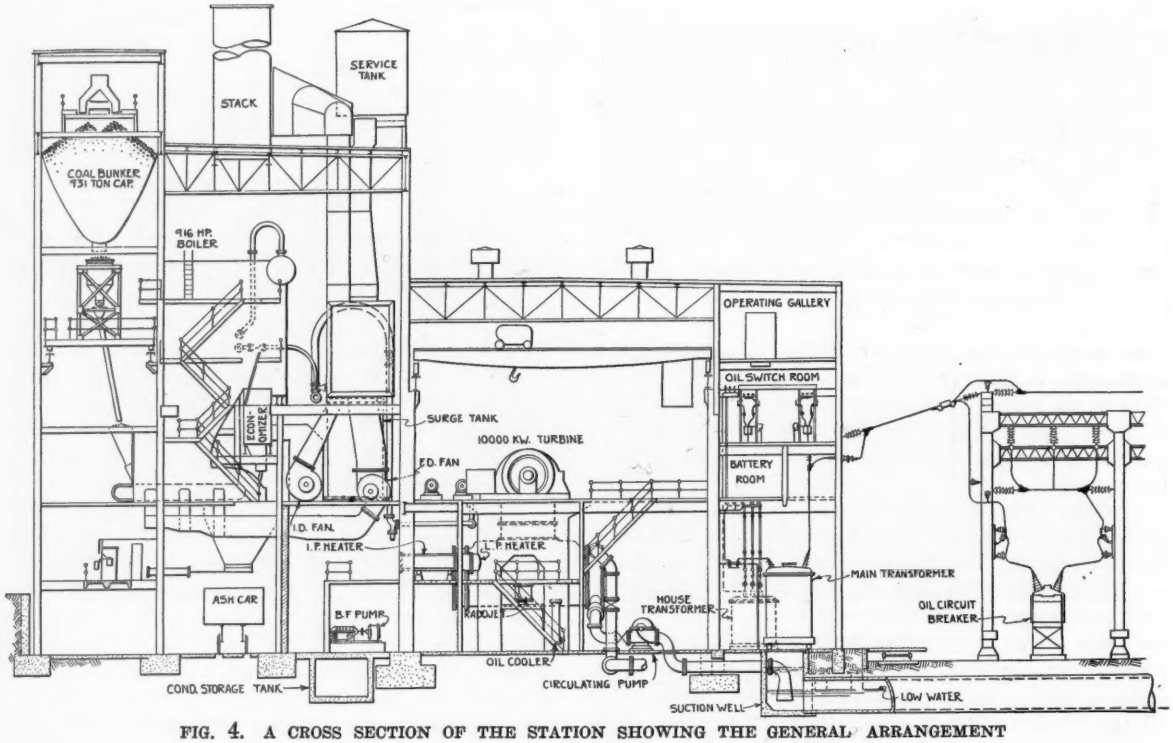


FIG. 4. A CROSS SECTION OF THE STATION SHOWING THE GENERAL ARRANGEMENT

by a remote control located on a panel on the main firing aisle opposite its boiler.

The peculiar shape of the furnace for anthracite does not make use of the volume below the back end of the boiler. This space was just sufficient for the installation of an economizer. The boiler was therefore designed with only two passes, the gases rising to the first pass and down through the second pass and entering the economizer, and from there to the induced draft fan and air heater. This made possible the grouping of all operating apparatus on the boiler room floor with easy access, and simplified the cost of construction of the boiler room building.

Heat Balance

Make-up water to the feed system is secured from a well adjoining the power plant with a capacity of better than 750 g.p.m., apparently tapping an extensive supply of sub-surface water. It is taken first to a roof tank for general house service. From there it is pumped

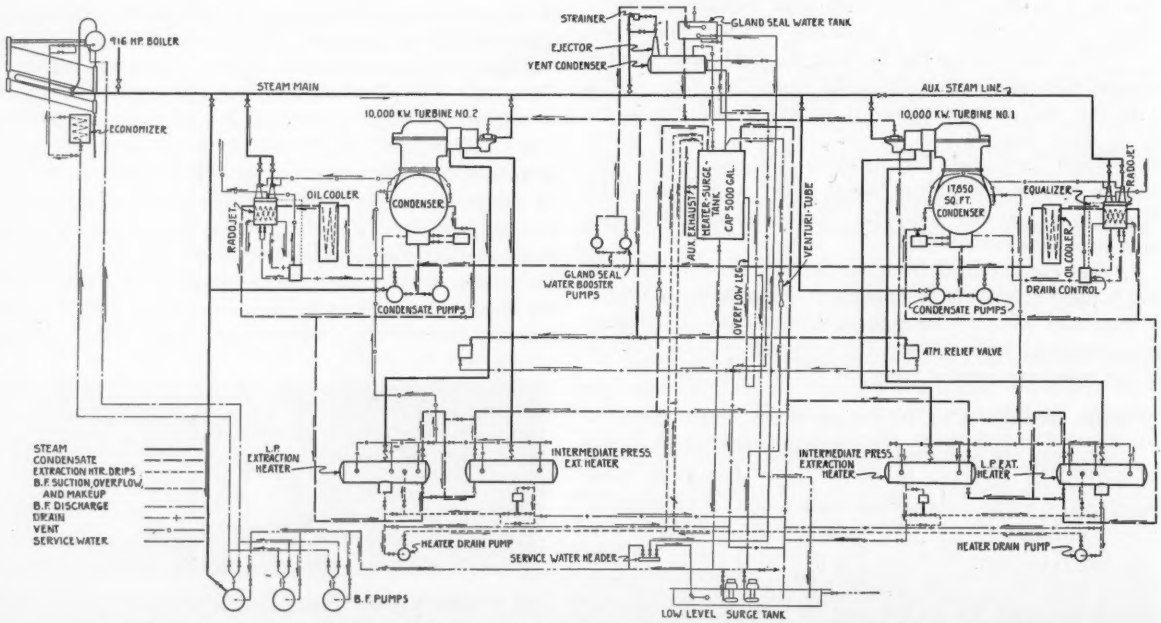


FIG. 6. STEAM IS EXTRACTED FROM THE MAIN TURBINE AT TWO PLACES FOR FEED WATER HEATING

directly into the surge tank to be pumped from there to the economizers by the boiler feed pumps. Exhaust steam is passed to the condenser and the recirculation of the condensate is achieved by a float chamber connected to the hotwell of each condenser, maintaining a constant level of water in the hotwells and insuring a constant supply of clean condensate through the oil coolers and radojets at all loads. Condensate emerges from the oil heater and air ejectors, under full load, at a temperature of 105 deg. and enters the low pressure heater supplied by steam bled from a lower stage of the turbine. It emerges from this at 169 deg. and enters an intermediate pressure heater supplied by steam bled

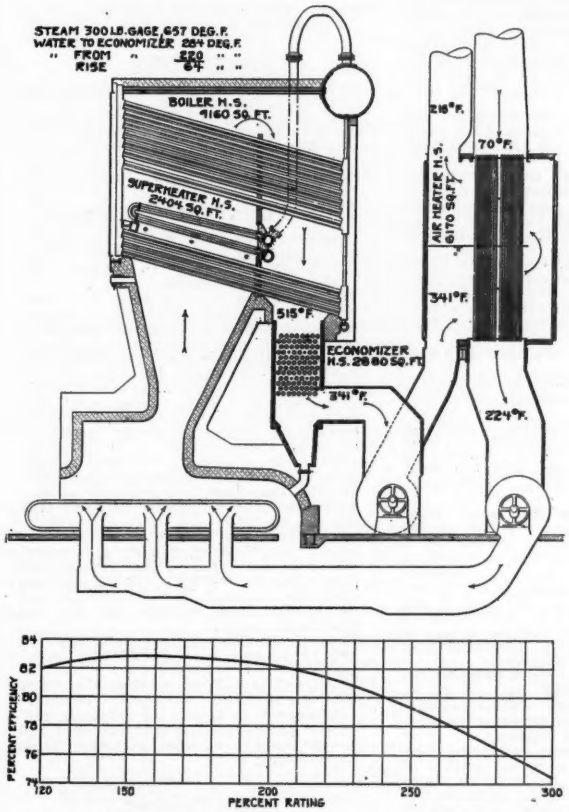


FIG. 5. EFFICIENCY INCLUDING BOILER, FURNACE, SUPERHEATER, ECONOMIZER AND AIR PREHEATER IS EXPECTED TO REACH 83 PER CENT

from a higher stage of the turbine where the temperature is increased to 227 deg. and passes to the surge tank from where it is pumped to the economizers entering them at a temperature of 221 deg.

Circulating Water

The present installation of the plant will call for 40,000 g.p.m. of water, including make up and other uses. Under low water conditions Whippany Creek will be incapable of supplying all this demand. Accordingly a spray pond was constructed, 80,000 sq. ft. in area, comprising 160 groups of 5 nozzles and with a capacity of 32,400 g.p.m. This is served by two 200-hp. motor driven spray pumps of 30,600-g.p.m. capacity each.

For the installation of this spray pond a new channel was excavated for Whippany Creek and dammed

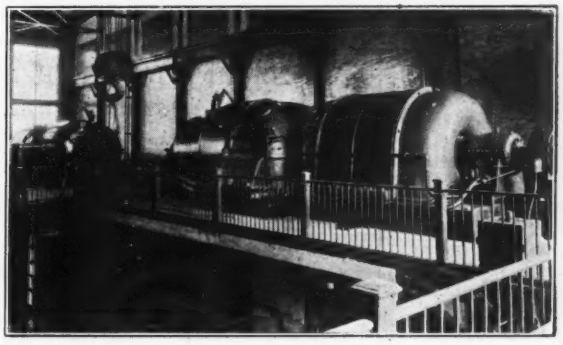


FIG. 7. THE RELIABILITY OF TWO 10,000-KW. TURBINES WAS CONSIDERED MORE IMPORTANT THAN THE SLIGHT INCREASED EFFICIENCY OF ONE 20,000-KW. UNIT

with a permanent sheet pile dam to elevation 189.5. At the entrance to the old channel a coarse screen was erected. The channel was cleared for a considerable distance and then sloped rapidly to a sump for removing the sediment. Passing through the sump the water flows to two 3/8-in. revolving screens of 17,000-g.p.m. capacity; self cleaning in that any refuse carried up on the screen is automatically washed off. From this screen the circulating water is lead through an intake and two 5-ft. concrete pipes to the two wells from which it is pumped to the condenser. It ultimately returns to a tank under the spray pond pump house. Here it is either released down stream to Whippany Creek or, if the water supply is low, pumped through the spray nozzles to the spray pond. Thus the circulating water uses all the water of the creek when below level 189.5 ft. and has a satisfactory source of supply arranged in even the driest season.

Electrical Design

Electrical designs offer some novelties planned throughout with the idea of dependability. For this reason each generator unit is operated at 6600 v. and is direct connected to its individual transformer, which is mounted on a truck on tracks so that it can be moved readily for examination or repair. Transformers are installed indoors in separate fireproof compartments.

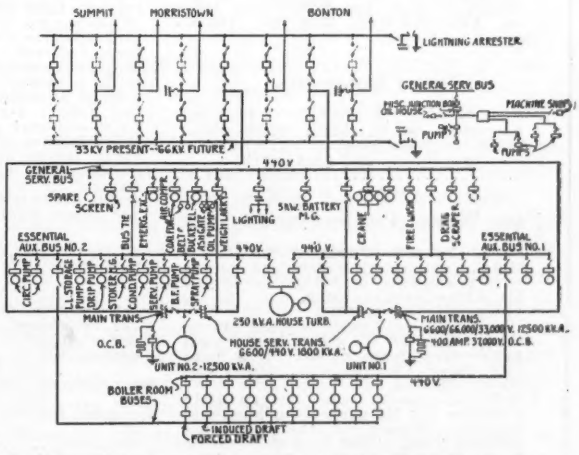


FIG. 8. EACH GENERATOR IS CONNECTED DIRECTLY TO THE LOW VOLTAGE SIDE OF SEPARATE TRANSFORMERS

Principal Equipment in Whippany Power Station

General

Location.....Whippany Creek, 2 miles north of Whippany, N. J.
Character of service....Central station
Capacity, present .....20,000 kw.
Capacity, ultimate .....40,000 kw.
Designed and built by.....
General Engineering and Management Corp.

Boilers and Superheaters

5 Springfield Boiler Co. 9160 sq. ft., 320 to 325 lb. gage operating pressure cross drum water tube boilers.
5 Power Specialty Co. Foster 2404 sq. ft. convection superheaters designed for 248 deg. superheat at 230 per cent rating or for a total temperature of 671 deg. at 300 per cent rating.
5 Power Specialty Co. Foster 2880 sq. ft. economizers (external heating surface).
5 Boiler settings with M. H. Detrick Co. air-cooled side walls and arches.

Miscellaneous Boiler Fittings

Safety valves.....
.....Consolidated Safety Valve Co.
Blowoff valves.....Yarnall-Waring Co.
Soot blowers.....
.....Diamond Power Specialty Co.
Gage glasses .....
.....Reliance Water Column Co.
Water columns.....
.....Reliance Water Column Co.
Feed water regulators.....
.....Northern Equipment Co.

Fuel Supply

Fuel ..... Anthracite
5 Combustion Engineering Corp. Type C stokers 11 ft. 8 in. wide and 70 ft. long with an effective grate area of 199 sq. ft.
1 Allen-Sherman-Hoff Co. coal Catenary section bunker, lined with cast iron plates supported by flat iron bands. Approximately 136 ft. long with a capacity of 6.5 t. per lineal ft.
Shaking feeder, vertical belt elevator, bucket conveyor and weigh larry..
.....Robins Conveying Belt Co.
Drag scraper.....R. H. Beaumont Co.
5 Allen-Sherman-Hoff cast-iron ash hoppers with cast iron plates and tile lining with two oil-operated gates per hopper.
5 Buffalo Forge Co. No. 6½ double inlet, double width forced-draft fans driven by 75-hp. Allis-Chalmers Mfg. Co. 440-v. slip ring motors. The capacity of each fan at 6 in. of water static head is 45,000 c.f.m.
5 Buffalo Forge Co. No. 7 double inlet, double width induced-draft fans with a capacity of 59,000 c.f.m. at 5½ in. of water. Each fan driven by a 100-hp. Allis-Chalmers Mfg. Co. 440-v. slip ring motor.

Draft Equipment

2 R. S. Newbold & Sons Co. 8 ft. 6 in. diameter, 70 ft. high, steel plate brick lined chimney.
Boiler breechings and duct work....
.....Connery & Co.

Feed Water Pumps and Heaters

2 A. S. Cameron Pump Works No. 3 H.S.T. centrifugal boiler feed pumps with a capacity of 325 g.p.m. driven by Allis-Chalmers Mfg. Co. 150-hp. 440-v. slip ring motors.
1 Worthington Pump & Machinery Corp. Class TS 325 g.p.m. centrifugal boiler feed pump driven by a Dean Hill Pump Co. 150-b.hp., 3600-r.p.m. steam turbine.
2 Griscom-Russell Co. intermediate pressure (24 lb. per sq. in. abs.) extraction heaters of the four-pass, floating head, closed type designed to heat 100,840 lb. of water per hr. from 168 to 227 deg. F.
2 Griscom-Russell Co. low pressure (6.5 lb. per sq. in. abs.) extraction heaters of the four-pass, floating head, closed type designed to heat 100,840 lb. of water per hr. from 97 to 168 deg.
1 Cochrane Corp. 254,000 lb. per hr. deaerater. Inlet water temperature, 216 deg. F.

Turbo-Generators and Condensers

2 Allis-Chalmers Mfg. Co. 10,000-kw. impulse reaction single flow turbine with multiple exhaust blading, and Two rows of impulse blading and 58 rows of reaction blading. Each turbine drives a 10,000-kw., 6600-v. 3-phase, 60-cycle, 1800-r.p.m. generator with 250-v. direct connected exciter.
1 Moore Steam Turbine Corp. 200-kw., 480-v. 3-phase, 60-cycle, 3600-r.p.m. house turbine.
2 C. H. Wheeler Mfg. Co. 17,850-sq. ft. divided water box, 2 pass, dual bank surface condensers with admiralty tubes.
2 C. H. Wheeler Mfg. Co. circulating water pumps with a capacity of 7650 g.p.m. each, direct connected to 50-hp. General Electric Co. 440-v., 3-phase, 60-cycle, 600-r.p.m. induction motors.
2 C. H. Wheeler Mfg. Co. No. 4 Class C condensate pumps with a capacity of 300 g.p.m. each. Direct connected to 20-hp. General Electric Co. 440-v., 3-phase, 60-cycle, 1800-r.p.m. induction motors.
2 C. H. Wheeler Mfg. Co. 2-stage radojets.
2 Griscom-Russell Co. U fin generator air coolers with a capacity of 36,000 c.f.m. each.
2 Chain Belt Co. vertical revolving water screens with a capacity of 17,000 g.p.m. each. Each screen driven by a 3-hp. Allis-Chalmers Mfg. Co. 440-v., 3-phase, 60-cycle, 1150-r.p.m. motor.
2 C. H. Wheeler Mfg. Co. spray pond pumps with a capacity of 30,800 g.p.m. each, each pump driven by a 200-hp. General Electric Co. 440-v., 3-phase, 60-cycle, 450-r.p.m. variable speed motor. The spray pond covers an area of 80,000 s[illegible] ft., has a capacity of 32,400 g.p.m. and consists of 160 groups of 5 nozzles designed to operate at 6½ lb. pressure and placed 5 ft. above the water.
1 Allis-Chalmers Mfg. Co. service water pump with a capacity of 400 g.p.m. Driven by a 25-hp. Allis-Chalmers Mfg. Co. 440-v., 3-phase, 60-cycle, 350-r.p.m. squirrel cage motor.
1 American Well Works low level outdoor service pump with a capacity of 600 g.p.m. Driven by a 40-hp. General Electric Co. 440-v., 3-phase, 60-cycle, 1150-r.p.m. squirrel cage motor.
2 American Well Works low level storage tank pumps with a capacity of 100 g.p.m. Driven by 7½-hp. General Electric Co. 440-v., 3-phase, 60-cycle squirrel cage motors.
2 Warren Steam Pump Co. drip pumps with a capacity of 36 g.p.m. each. Driven by 5-hp. Allis-Chalmers Mfg. Co. 440-v., 3-phase, 60-cycle, 1800-r.p.m. squirrel cage motor.
1 Worthington Pump & Machinery Corp. 100-lb. air compressor with a displacement of 170 cu. ft. per min. Driven by a 30-hp. Allis-Chalmers Mfg. Co. 440-v., 3-phase, 60-cycle, 1200-r.p.m. squirrel cage motor.

Miscellaneous Equipment and Materials

Steel, 1,958,000 lb.....
....Pittsburgh Bridge & Iron Works
Reinforced steel for concrete foundation, 100 t.....
.....Day & Goater & Igoe Bros.
Stairways and walks, 150,000 lb.....
.....F. G. Schaeffer Iron Works
Windows and steel sash.....
.....Truscon Steel Co.
Ventilators.....H. H. Robertson Co.
Soft glazed buff, face brick, 25,000..
.....A. F. Reed & Co.
Smooth gray face brick, 25,000.....
.....A. F. Reed Co.
Mottled gray "HYtex" salt glazed brick, 28,000 .....
.....Fredenburg & Lounsburg
Terra cotta, 5700 cu. ft.....
.....Atlantic Terra Cotta Co.
Floor tiles, 2818 sq. ft..A. F. Reed & Co.
Base cover 450 lineal ft.....
.....A. F. Reed & Co.
Lubricating oil system, filters and transfer pumps, oil purifiers.....
.....S. F. Bowser & Co.
Oil coolers.....Griscom-Russell Co.
High pressure steam system gate valves....Chapman Valve & Mfg. Co.
High pressure globe valves.....
.....Edward Valve & Mfg. Co.
High pressure pipe and fittings.....
..Pittsburgh Piping & Equipment Co.

Instruments

Boiler feed meters...Simplex Meter Co.
Indicating thermometers .....American Schaeffer & Budenberg Corp.
Recording thermometers...Foxboro Co.
Indicating gages .....
.....Crosby Steam Gage Co.
Recording gages.....Foxboro Co.

Main Electrical Equipment

2 Westinghouse Elec. & Mfg. Co. 12,500-kv.a., 3-phase, 60-cycle water-cooled, oil insulated, 6600 to 66,000 and 33,000-v. transformers.
2 Westinghouse Elec. & Mfg. Co. 1000-kv.a. self-cooled, 1800-kv.a. water-cooled, 3-phase, 60-cycle oil insulated 6600 to 440-v. auxiliary transformers.
10 General Electric Co. Type FKO-236-2452 A. S. 73,000-v., 400-amp., 3-pole single throw outdoor service electrically operated high voltage oil circuit breakers complete with mounting frame and tank lifting device.
2 General Electric Co. type FK-136-1328 A. S. 37,000-v., 400-amp. single pole single throw indoor service electrically operated high voltage oil circuit breakers complete with mounting frame and tank lifting device.
1 Allis-Chalmers Mfg. Co. motor generator set, 50-kw., 250-v., 1165-r.p.m. shunt-wound d.c. direct connected generator driven by a 440-v., 3-phase, 60-cycle squirrel cage motor acting as an auxiliary exciter set for the main generator.
1 Electric Storage Battery Co. type E. MG-13 60-cell storage battery complete.
2 Westinghouse Elec. & Mfg. Co. Type FV Auto-valve lightning arresters complete with frame for outdoor service. Each stack completely enclosed for protection against moisture from the cooling pond.

Main Control

1 General Electric Co. main switchboard with 9 front panels, 9 rear panels and 1 swinging bracket complete with instruments, wiring, instrument transformers and switching devices.
3 General Electric Co. auxiliary switchboards comprising two auxiliary units and one general service unit with a total of 36 panels and 3 swinging brackets. Complete with frame work, busses and connections, oil circuit breakers, disconnecting switches, instrument transformers, instrument switching devices and wiring on panels.
8 Leeds & Northrup Co. temperature recorders.
8 General Electric Co. 66,000 and 33,000 to 110-v., 60-cycle potential transformers oil filled for instrument, relay and synchronizing service.
1 Memco Engineering & Mfg. Co. outdoor switching station with 22 73,000-v., gang operated 3 pole single throw disconnect switches, complete with handle and interconnecting mechanism between poles, including insulator, 6 units for grounding attachments and 16 units without grounding attachments.
Structural steel fabricated by Newport News Shipbuilding & Dry Dock Co.

Both generators and primary wiring of the transformers, although operating at 6600 v. are full insulated for 13,200 v. Connections are flat bar copper instead of cables, feeding, through the transformers, two outdoor buses. From each of these buses there are single circuit lines to Morristown, Summit and Boonton respectively, the most important points in the territory.

Auxiliary service is furnished at 440 v. and the method of feeding this auxiliary power is somewhat unusual. There are three separate switching structures, two of which are interlocked through oil circuit breakers so that it is impossible to feed from one to the other while both generators are in service. Nor is it possible to feed the third bus from more than one generator at a time. For starting purposes a special 200-kw. turbo-generator is provided with direct connected exciter. This turbo-generator is also provided with a separate source of excitation by means of the station storage battery. This additional excitation source has been furnished in order that the turbo-generator will be able, in starting, to bring the essential motors of one unit up to full speed along with itself.

An additional feature of the auxiliary service is the so-called voltage chaser. By means of suitable relays, upon the dropping of voltage of one bus with two machines in operation, the tie breaker of the low voltage bus drops out and the breaker to the bus of normal voltage closes. Therefore there is no interruption in the essential motors required for plant operation as the failure of one of these to operate might, perhaps, shut down the entire plant.

The plant was constructed under the supervision of John Collins, Jr. and H. J. Bauer, with W. A. Shoudy acting in an advisory capacity on all matters pertaining to the design and construction.

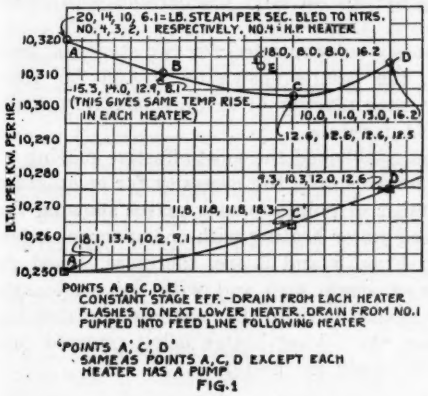
The early operation of the Whippany station indicates a high degree of efficiency and the new power supply will eliminate the present necessity of operating both the Morristown and Summit plants of the company which will be continued only as standby plants.

Extraction Heaters Increase Cycle Efficiency

EQUAL AMOUNTS OF STEAM BLED TO DIFFERENT HEATERS GIVE BEST RESULTS BUT PLACING OF HEATERS RELATIVELY UNIMPORTANT. BY K. S. KRAMER*

IN MAKING provision for the heating of feed water by means of steam extracted from the main turbine it is necessary to consider what will be the best feed temperature to employ for a given number of stages of heating and what gain may be anticipated from the use of one or more stages. As an approximate general guide toward the solution of any specific problem of this kind, curves giving the results of a series of calculations have been drawn and are reproduced here. In this study an effort has been made to approximate the conditions of actual practice by making allowance for losses due to pressure drop between the turbine cylinder and the heaters, depression of the heater condensate temperature, terminal difference and so forth. By terminal difference is meant the difference between the saturation temperature of the steam in the heater and the temperature of the outgoing water.

Having in view the modern tendencies toward higher pressures and larger units, steam conditions of 550 lb. gage per sq. in. 725 deg. F. total temperature, and 29 in. vacuum and a load of 70,000 kw. were used in all calculations. For convenience of calculation and in order that all points might be comparable, a constant stage efficiency of 82 per cent for the turbine elements was, with the exception of Fig. 2, used throughout.


20, 14, 10, 6.1 = LB. STEAM PER SEC. BLED TO HTRS. NO. 4, 3, 2, 1 RESPECTIVELY. NO. 4 = H.P. HEATER
18.0, 8.0, 8.0, 16.2
15.3, 14.0, 12.9, 8.1
(THIS GIVES SAME TEMP. RISE IN EACH HEATER)
10.0, 11.0, 13.0, 16.2
12.6, 12.6, 12.6, 12.5
9.3, 10.3, 12.0, 12.6
11.8, 11.8, 11.8, 11.8
18.1, 13.4, 10.2, 9.1
B.T.U. PER KW. PER HR.
10,320
10,310
10,300
10,290
10,280
10,270
10,260
10,250
POINTS A, B, C, D, E: CONSTANT STAGE EFF. - DRAIN FROM EACH HEATER FLASHES TO NEXT LOWER HEATER. DRAIN FROM NO. 1 PUMPED INTO FEED LINE FOLLOWING HEATER
'POINTS A', C', D' SAME AS POINTS A, C, D EXCEPT EACH HEATER HAS A PUMP
FIG. 1

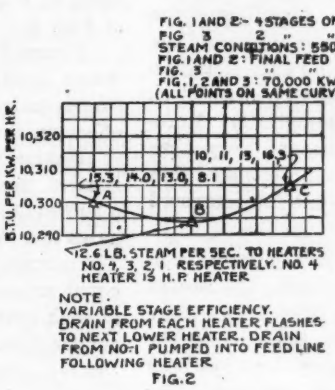
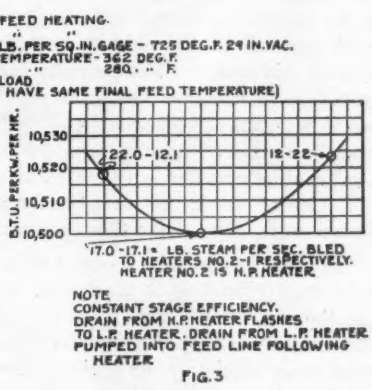


FIG. 1 AND 2 - 4 STAGES OF FEED HEATING.
FIG. 3 2 " " "
STEAM CONDITIONS: 550 LB. PER SQ. IN. GAGE - 725 DEG. F. 29 IN. VAC.
FIG. 1 AND 2: FINAL FEED TEMPERATURE - 362 DEG. F.
FIG. 3 " " " 280 " F.
FIG. 1, 2 AND 3: 70,000 KW. LOAD
(ALL POINTS ON SAME CURVE HAVE SAME FINAL FEED TEMPERATURE)
10, 11, 13, 16.3
15.3, 14.0, 13.0, 8.1
B.T.U. PER KW. PER HR.
10,320
10,310
10,300
10,290
12.6 LB. STEAM PER SEC. TO HEATERS NO. 4, 3, 2, 1 RESPECTIVELY. NO. 4 HEATER IS H.P. HEATER
NOTE: VARIABLE STAGE EFFICIENCY. DRAIN FROM EACH HEATER FLASHES TO NEXT LOWER HEATER. DRAIN FROM NO. 1 PUMPED INTO FEED LINE FOLLOWING HEATER
FIG. 2


22.0 - 12.1
12 - 22
B.T.U. PER KW. PER HR.
10,530
10,520
10,510
10,500
17.0 - 17.1 = LB. STEAM PER SEC. BLED TO HEATERS NO. 2 - 1 RESPECTIVELY. HEATER NO. 2 IS H.P. HEATER
NOTE CONSTANT STAGE EFFICIENCY. DRAIN FROM H.P. HEATER FLASHES TO L.P. HEATER. DRAIN FROM L.P. HEATER PUMPED INTO FEED LINE FOLLOWING HEATER
FIG. 3

FIGS. 1, 2 AND 3. WHEN CONDENSATE IS DRAINED TO NEXT LOWER HEATER THE MAXIMUM CYCLE EFFICIENCY IS INDICATED WHEN EQUAL AMOUNTS OF STEAM ARE BLED TO ALL HEATERS

The following assumptions were made and used in all calculations: Saturation temperature for pressure in heater is one degree less than saturation temperature for pressure in turbine; temperature of condensate in heater is 2 deg. less than saturation temperature for pressure in heater; and temperature of the feed water leaving each heater is 6 deg. less than saturation temperature for pressure in the heater.

Effective placing of heaters is the first question to be considered. By placing of heaters is meant their respective locations with reference to the pressure in the

*Large Turbine Engineering Dept., Westinghouse Electric and Mfg. Co.

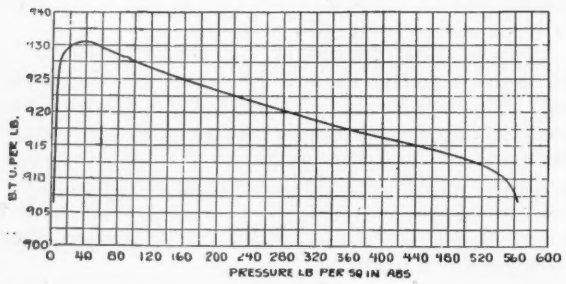


FIG. 4. THE MAXIMUM HEAT AVAILABLE FOR FEED WATER HEATING OCCURS AT ABOUT 36 LB. ABS. PER SQ. IN. PRESSURE

turbine stage from which the steam is supplied to each heater. The next question deals with the method to employ in disposing of heater condensate, that is, flashing back from each heater to the next lower or pumping the condensate of each heater into the feed line beyond the heater. The results of the calculations made to determine these points are shown on Figs. 1, 2 and 3. A curve is drawn through the points calculated with B.t.u. rate as ordinate, although with no value for abscissa. These results might have been given in table form, but the effect is probably more clearly shown by presenting the data in the form illustrated.

Referring to Fig. 1, it is evident that equal amounts of steam bled give the best results, but that placing of heaters matters very little. It is also evident that with correct placing of heaters, the better method of disposing of heater condensate is by flashing from one heater to the next lower heater and using a pump to pump the condensate from the coldest heater into the feed line beyond this heater. With correct placing of heaters, the gain due to using a pump for each one is so small as not to warrant the increased cost and complexity. Moreover, pumps having such small volume and very high head are not commercially built. It should be noted that the calculations do not take into account the increased power required to drive these pumps.

In Fig. 2, instead of constant stage efficiency, variable stage efficiency is used, but, as shown, the results are the same as in Fig. 1. Although Fig. 2 uses stage efficiencies which vary from the inlet to the exhaust, the same stage efficiency for a given pressure drop has been used for three points shown. The high pressure stages of the turbine in Fig. 2, as is the case in an average turbine, are less efficient than the low pressure stages. In other words, for each point calculated, a stage efficiency of 82 per cent was used for the B.t.u. drop from

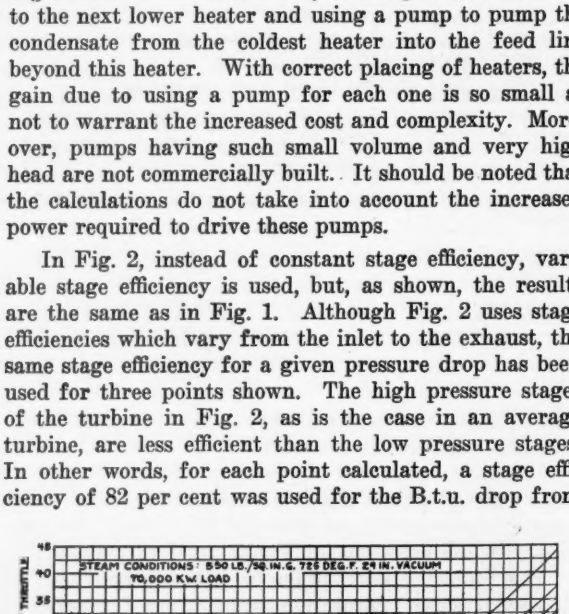

STEAM CONDITIONS 550 LB./SQ.IN.G. 725 DEG.F. 29 IN. VACUUM
70,000 KW. LOAD
1 STAGE
PERCENT INCREASE IN FLOW TO THROTTLE
FINAL FEEDWATER TEMP. DEG. F.

FIG. 5. STAGES OF HEATING USED INFLUENCES THE STEAM FLOW TO THE TURBINE THROTTLE

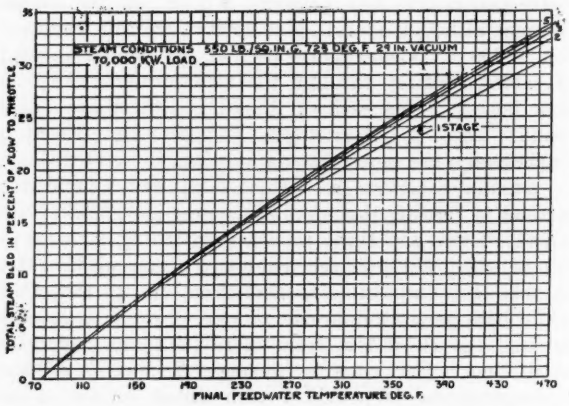

STEAM CONDITIONS 550 LB./SQ.IN.G. 725 DEG.F. 29 IN. VACUUM
70,000 KW. LOAD
1 STAGE
TOTAL STEAM BLED IN PERCENT OF FLOW TO THROTTLE
FINAL FEEDWATER TEMPERATURE DEG. F.

FIG. 6. TOTAL STEAM EXTRACTION AS A PER CENT OF THE TOTAL FOR A DEFINITE FEED WATER TEMPERATURE INCREASES WITH THE NUMBER OF HEATERS

550 to 286 lb, 83 per cent for the drop from 286 to 171 lb., and 83.5 per cent for the drop from 177 to 66 lb. These efficiencies were maintained for the respective pressure drops, regardless of from which pressure zones in the turbine the steam was bled for heating the feed. Each point on the curve, therefore, has the same internal efficiency and the change in B.t.u. rate is due solely to the varying of the pressures at which steam is bled. No attempt was made to have the average internal efficiency of the turbine for the points on Fig. 2 the same as for those on Fig. 1, so that the B.t.u. rates of Fig. 1 are not directly comparable with those of Fig. 2.

Figure 3 merely substantiates, for two stages of feed water heating, the results shown on Fig. 1 for four stages, namely that placing of heaters has very little effect on the B.t.u. rate.

Having thus established the most effective placing of heaters, there remains only the necessity for calculating a sufficient number of points to plot curves showing the gains due to feed water heating with one or more stages. The curves on Figs. 5 and 6 are, therefore, based on equal amounts of steam bled and with the condensate of each heater flashed back to the next lower heater, the condensate from the coldest heater being pumped into the feed line following the heater.

B.T.U. Available per Pound of Steam Bled

In order to facilitate calculation, the curve in Fig. 4 was drawn and is shown as a matter of interest. Of

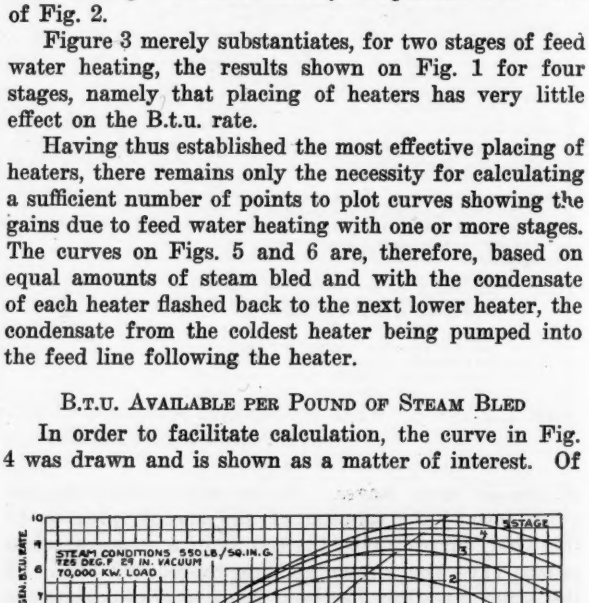

STEAM CONDITIONS 550 LB./SQ.IN.G. 725 DEG.F. 29 IN. VACUUM
70,000 KW. LOAD
1 STAGE
PERCENT DECREASE IN TURBO-GEN. B.T.U. RATE
FINAL FEEDWATER TEMP. DEG. F.

FIG. 7. FINAL ECONOMICAL FEED WATER TEMPERATURES INCREASE WITH THE NUMBER OF HEATERS USED

the total heat of each pound of steam bled, only a certain amount is available for heating the feed water, and this varies with the pressure in the turbine stage from which the steam is bled. The bled steam, passing through the heater, increases the temperature of the feed water and in so doing, is condensed, the temperature of this condensate being some 3 deg. less than the saturation temperature corresponding to the pressure in the turbine stage from which the steam is bled. The amount of heat per pound of steam bled, which is available for heating the feed water, is, therefore, the difference between the total heat of the steam bled and the heat of the liquid of its condensate. As indicated in Fig. 4, the maximum B.t.u. available for heating the feed occurs at a pressure of about 36 lb. sq. in absolute. Figs. 5 and 6 are also shown as a matter of interest to indicate the per cent increase in throttle flow for various final feed water temperatures and for various stages of heating.

Decrease in turbo-generator B.t.u. rate with various final feed water temperatures and for steam bled from one to five stages is shown on Fig. 7. From these curves, the best final feed temperatures can readily be obtained, together with the gains due to increasing the number of stages. Although these curves have been worked up for specific steam conditions, they should be applicable for other conditions, not deviating too far from those used for this study. Summarizing the above, the main points are: first, that within reasonable limits the placing of the heaters along the line of expansion makes very little difference on the B.t.u. rates; second, that with correct placing of heaters, the better method of disposing of heater condensate is by flashing back from one heater to the next lower heater and using a pump to pump the condensate from the coldest heater into the feed line following this heater; and third, as shown by the curves on Fig. 7, the additional gain obtained by increasing the number of stages of feed water heating decreases very rapidly as the number of stages of heating is increased. It would seem that in general feed water heating with more than five stages would not warrant the additional investment required.

Centrifugal Action Purifies Oil

CENTRIFUGAL FORCE REMOVES SOLID PARTICLES AND SEPARATES LIQUIDS OF DIFFERENT DENSITY. BY HENRY MOORE*

APPLICATIONS OF CENTRIFUGAL separation in the petroleum field cover a wide range, from the manufacture of bright stocks and the recovery of bottom settlings in the refineries, to the continuous purification of naphtha for the dry cleaner who cleans your clothes. Between these extremes are the applications which have to do with oils used in power plants such as: insulating oils, lubricating oils and fuel oils.

Oil purification is accomplished in the Sharples Super Centrifuge as indicated in Fig. 1. Centrifugal force is comparable with that of gravitation except in its intensity and direction of action.

Centrifugal force generated in the commercial Super Centrifugal bowls varies from 13,000 to 15,000 times the force of gravity. Our laboratory model develops a force 40,000 times that of gravity. When the mixture is placed in the rotating bowl, the effect of gravity is negligible in comparison with that of centrifugal force, which acts at right angles to the axis of rotation. The mixture tends to separate into a layer of solids at the periphery of the bowl, an intermediate layer of water, and a layer of oil floating on the inner surface of the water. The discharge holes of the bowl top are so provisioned that water can be drawn off from the periphery of the bowl and discharged into one cover. The oil is drawn from the surface of the water and discharged into the other cover. The solids deposit against the wall of the bowl, and are cleaned out at the end of the run.

The super centrifuge may be equipped with either a separator or clarifier bowl. When solid alone is to be removed from a liquid the clarifier bowl is used. This bowl has but one set of outlet ports from which the liquid discharges continuously during operation. Solids deposit in the bowl.

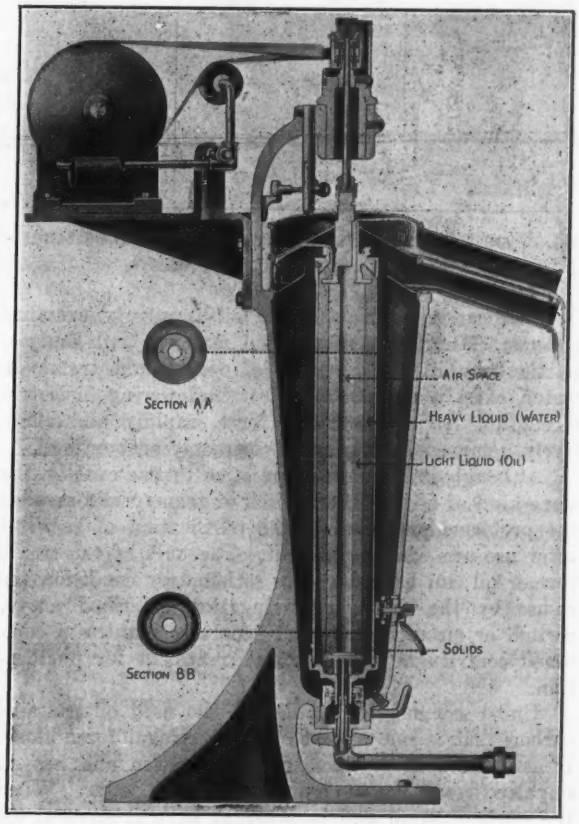


FIG. 1. SHOWING HOW IMPURITIES ARE SEPARATED OUT IN A SHARPLES SUPER CENTRIFUGE

Centrifugal purification of insulating oils is interesting in that it brings out the very important fact that it is not so much the kind, grade or weight of oil as the

*The Sharples Specialty Co., Philadelphia, Pa. From a paper presented at the Oil Power Conference held April 22, 1927, at State College, Pa.

use to which it is put, which determines the proper method of centrifugal purification. Purification of insulating oil, after use in a transformer, is an entirely different problem from its purification after use in a circuit breaker or switch.

Centrifugal treatment of transformer oil involves the removal of water, sludges formed by decomposition of the oil, particles from deteriorated insulating materials and similar solids that are introduced during the handling and use of the oil. In removing these foreign materials, the oil is restored to the high dielectric strength necessary for the proper operation of transformers. The process consists in heating the oil to about 50 deg. C., feeding it to the machine at a rate of from 400 to 600 gal. per hr. on large units and returning the purified oil to the transformer. With the rare exception of wet and dirty oils that have very low dielectrics, one pass through the machine is sufficient to secure a dielectric above the required value of 22.0 kv.

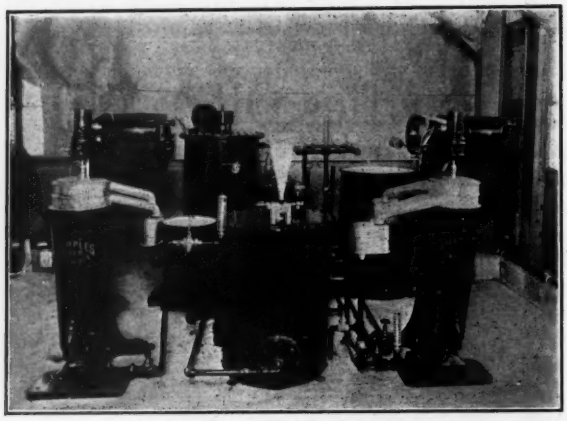


FIG. 2. COMPLETE TREATING UNIT FOR CONTINUOUS PURIFICATION OF LUBRICATING OILS

Purification of transformer oil is a very exacting process. Minute traces of solid material and sludges, particularly in the presence of very slight traces of water, exert a remarkable effect in lowering dielectric strength. High centrifugal force, rapidly and effectively, removes the impurities commonly encountered.

Although it is common practice to use exactly the same kind of oil in either switch or transformer service, the problems presented in the purification of such oil after use are widely different. The bulk of the transformer oil can be restored to satisfactory condition for re-use by the simple centrifugation described above. Switch or circuit breaker oil generally requires a combined centrifugal and chemical treatment for purification.

Under commercial conditions, the used oil contains carbon that is not removed by centrifugal force alone. It contains acid products of deterioration and has an impaired resistance to emulsification with water. When the contamination and impairment have progressed too far, the oil must be processed and no method has proven quite as satisfactory as the following: The oil is mixed with a dilute sodium silicate solution, the mixture heated and then separated. This operation removes carbon and reduces the acid value of the oil to a sufficiently low figure. The resistance to emulsification is improved and the oil given a final clarification by treating with a small amount of decolorizing earth by heating and centrifuging. Figure 2 illustrates a complete treating unit. The apparatus is used to carry out the above described steps continuously, being supplied with pumps, agitators, heaters and controls for the proper handling of reagents and treatment of the oil.

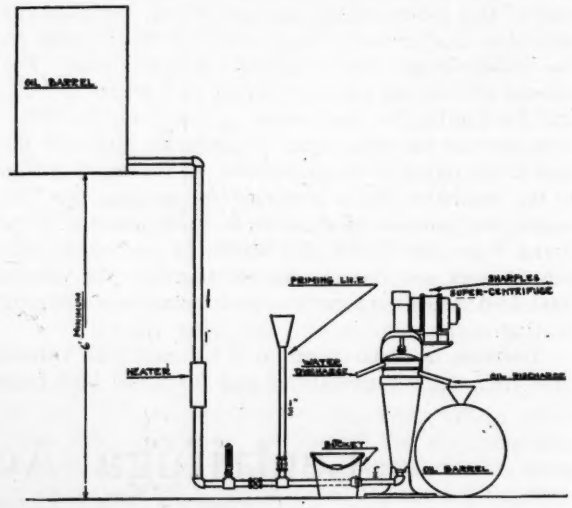


FIG. 3. DIAGRAMMATIC ARRANGEMENT OF APPARATUS FOR RECLAIMING SMALL BATCHES OF LUBRICATING OIL

Purification of Lubricating Oils

Lubricating oils of all kinds are purified for re-use by treatment in a super centrifuge. The most important differentiation, however, between lubricating oil purification methods is in the batch system as opposed to the continuous system of purification.

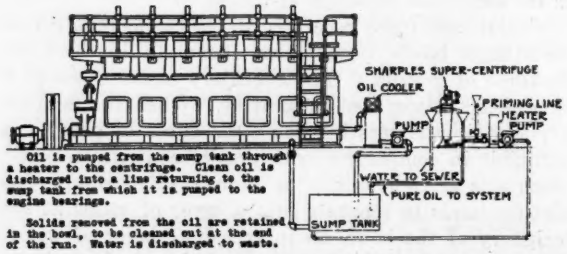

SAMPLES SUPER-CENTRIFUGE
OIL COOLER
PRIMING LINE
HEATER PUMP
PUMP
WATER TO SEWER
PURE OIL TO SYSTEM
SUMP TANK
Oil is pumped from the sump tank through a heater to the centrifuge. Clean oil is discharged into a line returning to the sump tank from which it is pumped to the engine bearings.
Solids removed from the oil are retained in the bowl, to be cleaned out at the end of the run. Water is discharged to waste.

FIG. 4. DIAGRAMMATIC ARRANGEMENT FOR THE CONTINUOUS PURIFICATION OF LUBRICATING OIL IN LARGE QUANTITY

Batch purification is useful for small quantities of oil obtained from units where sight feed, or mechanical force lubricators supply relatively small quantities of oil to the lubricated parts. In many cases, the only treatment necessary is a simple centrifugation assisted by heating to lower viscosity, hence increasing the efficiency of the centrifugal treatment. In other cases, where the oil is badly contaminated with carbon, sludges, and other impurities, treatment of the oil before centrifugation is sometimes necessary. To remove carbon, heating and agitating the oil with dilute alkaline solutions is very effective. Figure 3 shows a diagrammatic

set-up for reclaiming batches of lubricating oil that are used and collected in fairly small quantities.

Continuous purification is recommended where engines, or other units, have oil reservoirs from which the oil is pumped to lubricated parts and to which the oil drains after it has performed its function. In large engines and units in which the rate of flow of oil through the bearings is usually at a high rate, the arrangement shown in Fig. 4 is used. Under such a plan the circulation of the oil to the lubricated unit is entirely separate from the circulation of the oil through the purification equipment and either operation can proceed independently.

Figure 5 illustrates the method employed for purification of turbine oil. The oil is drawn from the very bottom of the pump where it is dirtiest and passed to the centrifuge. Yet the drawoff is so regulated that the oil level never falls below a definite point, hence there is no danger of failure of the oil supply.

Diesel lubricating oil is subject to contamination from various sources such as carbon resulting from incomplete combustion of the fuel in the cylinders; water from condensation of atmospheric moisture in the crankcase and from leaks which may occur in cooling system of the engine; and dust of various sorts entering the crankcase from the air; metallic particles resulting from wear of parts in the engine; sand from cast part of the engine; and thick oily sludges resulting from de-

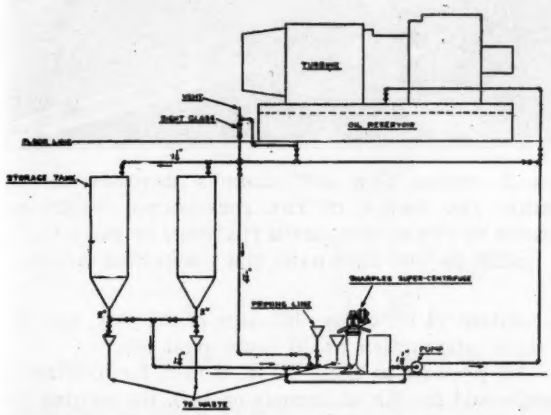


FIG. 5. METHOD USED FOR PURIFYING TURBINE OIL

composition of the oil under the high temperatures of engine operation.

Sand, dirt and metal particles cause abrasion of lubricated parts, water may replace oil in bearings and hence cause bearing seizure. Carbon and oil sludges, together with other solid materials, form deposits which interfere with the operation of oil pumps and clog oil lines and passages so that insufficient lubricant is received at lubricated point.

Experience has demonstrated that properly purified oil may be used almost indefinitely, and that it is not necessary to discard the contents of an engine crank case at intervals. Furthermore with a good purification system wear on lubricated parts is reduced so that bearing adjustment and repairs are kept at a minimum.

Operation with low grade fuels results in difficulties caused chiefly by water, solid matter and ash-forming constituents. Centrifugal treatment removes water and solid matter almost completely from fuels and materially reduces ash-forming constituents. Hence the cheaper grades of fuel oil may be used.

Water unevenly distributed in fuel oil will cause erratic firing or even misfire, and sand, rust and dirt injected in cylinders with the fuel will cause wear on pistons, liners and bearings if the unburned oil from the cylinders enters crankcase oil.

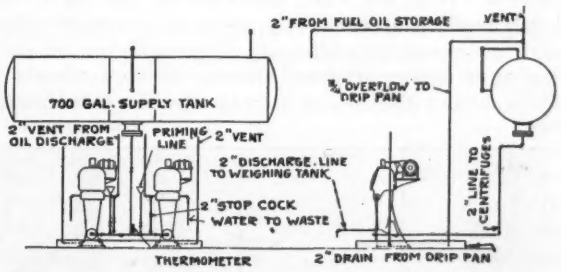


FIG. 6. TYPICAL ARRANGEMENT OF TWO SUPER CENTRIFUGES USED WHERE CONSIDERABLE HEATING IS DESIRABLE

A typical layout of two Presurtite Super Centrifuges is shown in Fig. 6. This installation was made by the engine builder to clean fuel used in testing a 3900-hp. engine for the U. S. Shipping Board. These machines, running one at a time cleaned over 140,000 gal. of fuel oil of 25 deg. Bé. gravity in 30 days removing 1478 lb. of "muck" that would otherwise have entered the engine fuel system. An analysis of the material removed is given below.

Constituents	Percentages	Total Weight Removed
Water	27.20	402 lb.
Oil (petroleum ether extract)	41.40	608 lb.
Asphaltenes (carbon bisulphide extract)	13.17	195 lb.
Carbon fibre, etc. (combustible residue)	9.08	134 lb.
Ash (non-combustible residue)	9.41	139 lb.
Totals	100.00	1478 lb.

The Presurtite machine shown finds one of its ideal applications on fuel where it is necessary to heat near to or above the flash point of the oil for proper purification. It prevents escape of the dangerous vapors from the oil into the air. Heavy oils particularly require heating to facilitate centrifugation.

REVIEWING the work of the Engineering Foundation for the past year, among the most important activities have been investigations on the fatigue of metals, cooperation with the investigation now going forward for the improvement of engineering education, studies on the nature of slags, study of electric insulating materials, study of steel columns for bridges and buildings, and the carrying forward of the work on arch dam investigation by the making and testing of models of dams to various scales and the construction work on the experimental dam at Stevenson Creek which is now 60 ft. high and 143 ft. long, and may later be raised to 100 ft. high. It is proposed to test this dam to destruction after a series of tests of deformation.

Glass Plant Has Varied Power Demands

BLEEDER TURBINE OPERATING IN CONJUNCTION WITH CENTRAL STATION POWER USED TO IMPROVE HEAT BALANCE IN THE REMODELED PLANT OF THE ILLINOIS GLASS CO.

WHEN WE SEE one of the 5-gal. bottles in the water cooler, it is difficult to realize what a small amount of direct human labor has been employed in its manufacture and to what extent power enters into the process. It is not until one looks at the big Owens bottle machine automatically operated by electric power and compressed air; revolving, dipping down and sucking up a charge of glass, blowing the 5-gal. bottle in the mold and discharging it on the opposite side through

FIG. 1. VIEW OF THE TURBINE PLATFORM AS SEEN FROM THE ENGINE ROOM CRANE

a power-driven conveyor to be tempered in electric heated lehrs, that we realize to what extent power is employed in the modern glass industry.

Recently the Illinois Glass Co. at Alton, Illinois, remodeled its power plant and installed new equipment to take care of the added power demand. Jackson & Moreland, of Boston, working with the engineering staff of the Illinois Glass Co., handled the engineering and construction work.

The plant can be tied in with both Keokuk or with two lines from Cahokia power stations through opposite ends of the 23 panel switchboard. Two busses, normally in parallel on the Cahokia lines, are provided, each large enough to care for the entire plant load. Both lines are equipped with reverse current relays so that in case of trouble on one line, the load will be picked up on the other without interrupting the service in the plant. Incoming secondary lines to the switchboard are both 440 v., and no high tension switching is done at the station, the transformers all being located outside the power plant.

About 30 per cent of the total power is used in the electrically heated lehrs and at present the maximum 30 minute demand runs about 2100 kw. Due to this non-inductive electric lehr load and the large number of synchronous motors driving direct connected compressors and vacuum pumps, the power factor is in the neighborhood of 92 per cent. In addition to the two power company busses, there is a third bus supplying the essential service, consisting of deep well pumps and direct current supply for the lehrs, revolving pots, gas producers, stokers, coal feed, cooling tower fans. This bus is not ordinarily connected with the other two but is supplied by the company's 1000-kw., 80 per cent power factor, 480-v., 3-phase, 60-cycle, 3600-r.p.m. Allis-Chalmers bleeder type turbine. Reliability is one of the prime requirements of the power service. The load

FIG. 2. THREE NEW SYNCHRONOUS MOTOR-DRIVEN MACHINES ARE VISIBLE IN THE FOREGROUND, WHILE THE CORNER OF THE TURBINE ROOM PLATFORM OF FIG. 1 CAN BE SEEN ON THE LEFT-HAND SIDE ABOVE THE CLOCK

is constant 24 hr. a day, 365 days of the year, and even a short interruption would cause great loss.

Air pressure at about 40 lb. is used for blowing the bottles and for the oil burners on both the melting pots and lehrs, while 80 lb. air is used to operate the Owens 5-gal. bottle machine and 100 lb. air is used for general service and pneumatic tools throughout the plant. A vacuum system with a vacuum of about 24 in. connects with all machines and is used to suck up the charges of molten glass from the revolving pots. A comprehensive color scheme has been adopted for all pipes, as indicated in the table.

Non-condensing turbine auxiliaries and steam driven vacuum pumps and compressors exhaust to the heating main at about 7 lb. pressure. Additional requirements for heating are made up by steam bled from the bleeder type turbine. At such times as no steam is required for heating, the exhaust from compressor and vacuum pumps is automatically fed into the turbine, which operates as a mixed pressure unit under this condition. This turbine is set over an Elliott surface condenser equipped with a single-stage 125-lb. steam air-ejector and surface after cooler. The after cooler is supplied with condensate which under normal conditions leaves

the cooler in the neighborhood of 103 deg. F. Circulating water from the cooling tower is supplied by a DeLaval centrifugal pump with duplex drive consisting of a 30-hp. General Electric motor and a 30-hp. Kerr non-condensing turbine. Excitation is furnished by one of two 15-kw., 1740-r.p.m., 120-amp., 135-v. Allis-Chalmers shunt wound 40 deg. temperature rise exciter, one driven by an Allis-Chalmers 23.5-hp., 40-deg. temperature rise, 440-v., 3-phase, 60-cycle motor, the other driven by a Kerr Type 3C, 25-hp., 1750-r.p.m., 150-lb., 100-deg. superheat non-condensing steam turbine.

Well water used for make-up is softened by a Permutit softener and steam is supplied by five boilers. Because of the old and new equipment, both superheated and saturated steam are used, saturated steam at 140 lb. gage being supplied by three 280-hp. Springfield boilers fired by Illinois natural draft chain grate stokers.

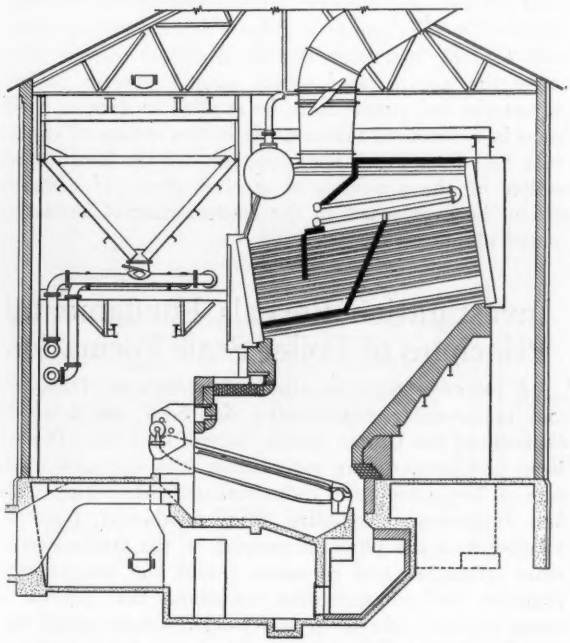


FIG. 3. THE NEW BOILER IS OF THREE-PASS TYPE

Superheated steam is supplied by one 500-hp. Badenhausen boiler fired by an Illinois forced draft chain grate stoker and by a new 500-hp. Heine boiler fired by a Stowe forced draft chain grate stoker with the setting shown in Fig. 3. Both of these boilers are equipped with Foster superheaters. Forced draft, supplied by two Sturtevant fans, is used and will replace the individual blowers on the Badenhausen.

Two Sturtevant ash pit blowers were installed in conjunction with the Badenhausen boiler at the time it was put in. These blowers are being replaced by the new forced draft equipment, which consists of two Sturtevant fans, one motor driven and one turbine driven which discharge in a duct system connecting to the new Heine boiler and the old Badenhausen boiler. The three Springfield boilers will continue to operate on natural draft.

Additional compressor and vacuum pump capacity was needed, and two 27 by 24 duplex 40-lb. Worthington feather valve air compressors with a displacement of 5000 c.f.m. each were installed. These machines have a five step volume control and are driven at 164 r.p.m. by 650-hp. Electric Machinery Mfg. Co. Type EFG, 440-v., 3-phase, 60-cycle, 100 per cent power factor synchronous motors, excited by 33⅓-kw. exciters. A new 43 and 23 by 20 two stage Worthington feather valve vacuum pump driven by a 300-hp., 440-v., 3-phase, 60-cycle, 180-r.p.m. Electric Machinery Mfg. Co. synchronous motor mounted directly on the crank shaft was installed at the same time.

PIPE LINES ARE ALL MARKED WITH A COLOR CODE SO AS TO BE EASILY DISTINGUISHABLE

Pipe Lines	Color
Vacuum lines	Yellow
Saturated steam	White and green
Superheated steam	White and black
Air lines	Brown
Traps and drains	Orange
Exhaust steam	White and red
Water mains	Blue

Both of the new compressors as well as the cooling air duct for the generator are equipped with Midwest unit air filters. Each machine has six units, the total capacity of the 18 units being 15,000 c.f.m. at a pressure drop of 0.37 in. water gage.

Many Factors Govern Slagging of Furnace

ONE OF THE MOST serious causes of failure of refractories in boiler furnaces fired with coal is the erosion by slag from the coal ash. The total expense incident to this and other types of failure has become so great that there has been a marked tendency in the past two years to protect or entirely replace by water or steam-cooled surfaces the refractories in the areas most seriously affected. Some modern boilers have no refractories within the furnace.

Factors governing the slag erosion are divided into two classes in a recent progress report of the A. S. M. E. Research Committee on Boiler Furnace Refractories, first, service factors dependent on the type of coal burned and the method of coal burning, and second, refractory factors dependent on the type of clay used and the method of manufacturing.

In this investigation the main objective is to supply information to the ceramic engineer to aid him in the study of the mechanism of slag erosion and other causes of failure and enable him to designate the proper application of the present refractories, or point to the development of other refractories.

Service factors are considered to govern slag erosion directly, and are being experimentally investigated in the field for various coals and coal burning equipment, refractory temperatures, furnace gas temperatures, furnace gas composition, furnace gas velocity, slag composition and slag quantities. At this time values for part or all of these factors have been determined under each of the following set of conditions, eastern bituminous coals on underfeed stokers, powdered eastern bituminous coals in furnaces with extensive radiant heat absorbing surfaces, high sulphur Pittsburgh coal on

underfeed stokers, low sulphur Pittsburgh coal on underfeed stokers, high sulphur Pittsburgh coal on chain grate stokers, Illinois coal on chain grate stokers and powdered Illinois coal.

Arranged in the order of increasing severity of slag erosion, the furnaces studied were placed as follows: underfeed stokers, chain grate stokers, powdered coal. Although other reasons for this varying severity of surface with different types of firing have been pointed out, it is interesting to observe that the values for the quantities of slag carried in the gases fall in the same order. Of course, the severity of service does not increase in the same proportion as the quantity of ash because only a certain amount of slag can attack the walls. Beyond the point at which slag is deposited, as fast as emulsion combination runs away, further additions probably do not increase the action.

Steam Accumulators for Industrial Plants

IN THE DISCUSSION on the use of power in industrial plants at the A. S. M. E. regional meeting held at Erie, Pa., recently, R. A. Langworthy emphasized the importance of considering the use of steam accumulators in modernizing industrial power plants. The steam accumulator, said Mr. Langworthy, deserves more prominence than it has had in this country. As a means of modernizing industrial power plants, saving fuel and increasing production, it has an important field.

There are over 300 installations in Europe and 12 in the United States and Canada but it is comparatively unknown in this country and its possibilities are fully appreciated by but few engineers. When the value of this piece of equipment to industry is realized its adoption is sure to proceed rapidly.

The special field of the steam accumulator lies in industrial plants having fluctuating demands for steam and there are many such. When applied to plants of this character it has produced some remarkable results. No other method of meeting the situation will even approximate them.

By storing steam during periods of light demand and releasing it instantly to meet peaks, it maintains a constant load on the boiler plant, which results in fuel economy, reduced maintenance and the ability of the boiler plant to carry the load with less installed capacity. It is a "shock absorber" between the boiler plant and the factory load.

Another feature of great importance lies in the fact that the installation of an accumulator renders the process work in the factory entirely independent of the boiler plant. The proper steam demands of the process are quickly and fully met at all times. This often results in increased production without any additional investment in factory equipment, a fact which has been actually demonstrated in many plants. It is surprising how many factories are handicapped in their process work by inadequate steam supply, due to the inability of the boiler plant to supply the steam demand promptly. The inherent characteristics of the boilers and firing equipment in the average industrial plant are not of a character to meet the load conditions imposed upon them. The plant management very frequently does not realize the fact that lack of steam slows up their production. The fact is fully appreciated in many cases only after the installation of an accumulator has actually increased production.

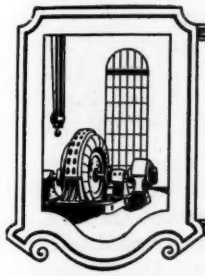
With regard to the possibilities of generating electric power from the process steam, in many instances investigations along this channel have encountered the fact that the steam load and electric load do not synchronize so that the maximum amount of power cannot be obtained except by wasting steam during some periods. Here again the steam accumulator supplies the missing link and when properly designed and co-ordinated with the balance of the system, it enables the maximum amount of process power to be generated without wasting steam.

While the principle of steam accumulation is old, it was not until after the study and development work of Dr. Ruths that it could be practically applied to industrial plants. The modern development of this principle has been in the form of a definite scheme of application and control, including special governor valves which make the accumulator steam storage system entirely automatic and enable it to be applied to diverse conditions in a practical manner. It is this system of control with its valves which has made possible the broad application of the accumulator to industry. It certainly cannot be overlooked in the modernizing of industrial power plants.

Investigation Reveals Fundamental Principles of Boiler Scale Formation

A PHYSICO-CHEMICAL study of boiler-scale formation and boiler-water conditioning has been completed by chemists of the United States Bureau of Mines, Department of Commerce, in cooperation with Carnegie Institute of Technology and industrial interests. This is the first fundamental scientific study conducted, from the viewpoint of the physical chemist, of the mechanism of scale formation and corrosion under the temperature, pressure, and concentration conditions that prevail in steam boilers. The study has yielded fundamental data on which to prescribe a rational chemical treatment of boiler water, information which has been lacking in the past. The results of the investigation should tend to promote real conservation of fuels and boiler equipment and therefore offer an opportunity of effecting considerable savings in the nation's fuel bill. Fuel losses due to the formation of boiler scale run into enormous figures.

A report containing the results of this investigation has just been issued as Bulletin 24, Mining and Metallurgical Investigations, by Carnegie Institute of Technology. The authors of the bulletin are R. E. Hall, physical chemist, United States Bureau of Mines, J. A. Robb, H. S. Karch and E. A. Hertzell, research fellows, Carnegie Institute of Technology, and G. W. Smith and H. A. Jackson, chemical engineers, Hagan Corporation. The bulletin discusses the principles of boiler-water conditioning; the solubility of calcium sulphate, barium sulphate, and calcium phosphate at boiler-water temperatures; relation of hydroxyl ion to the inhibition of corrosion; the non-condensable gases of the steam; and the increment of soluble and insoluble solids in boiler water. Copies of this bulletin may be obtained from Carnegie Institute of Technology, Pittsburgh, Pa.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Use of Reclosing Equipment on A. C. Lines

PART II. DESCRIBING THE ACTION OF RECLOSING EQUIPMENT BY MEANS OF A TYPICAL WIRING DIAGRAM. BY A. E. ANDERSON*

IN ORDER TO STUDY the action of automatic reclosing equipment it is best to refer to an elementary wiring diagram of a typical a.c. reclosing feeder such as is shown in Fig. 1. The various over-current tripping connections, discussed in the first part of this article are shown at the left.

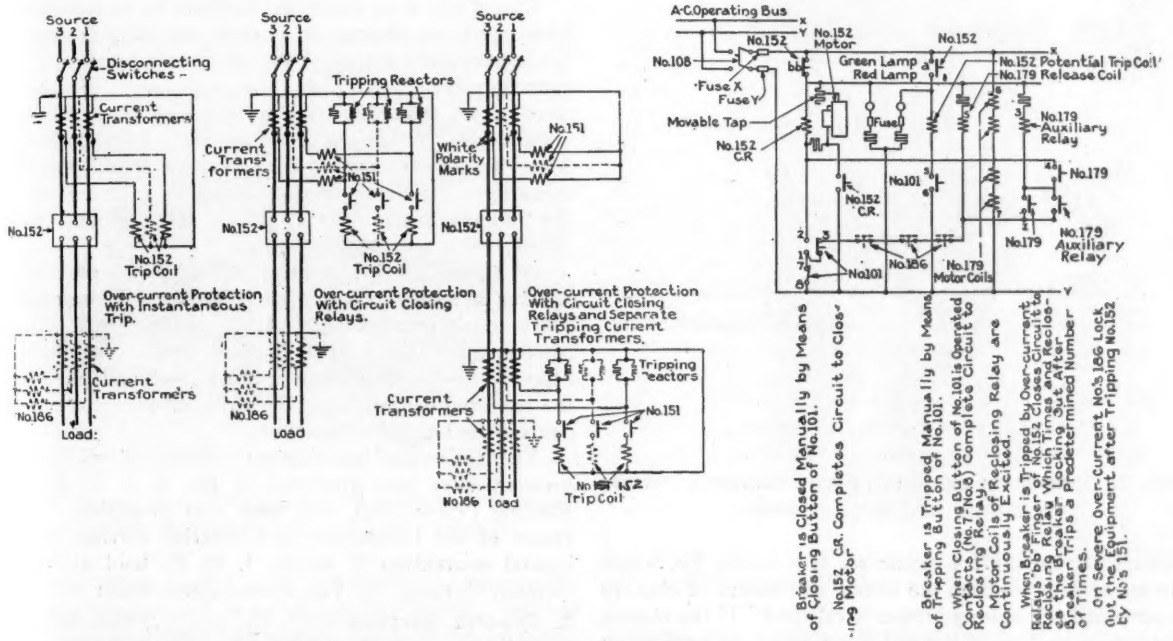

Source
3 2 1
Disconnecting Switches
Current Transformers
No.152
No.152 Trip Coil
Over-current Protection With Instantaneous Trip.
No.186
Load
Tripping Reactors
Current Transformers
No.151
White Polarity Marks
Over-current Protection With Circuit Closing Relays.
Over-current Protection With Circuit Closing Relays and Separate Tripping Current Transformers.
A-C Operating Bus
No.152 Motor
No.108
Fuse X
Fuse Y
Movable Tap
No.152 C.R.
Green Lamp
Red Lamp
No.152 Potential Trip Coil
No.179 Release Coil
No.179 Auxiliary Relay
No.101
No.156
No.179 Motor Coils
Breaker is Closed Manually by Means of Closing Button of No.101.
No.152 C.R. Completes Circuit to Closing Motor
Breaker is Tripped Manually by Means of Tripping Button of No.101.
When Closing Button of No.101 is Operated Contacts (No.7-No.8) Complete Circuit to Reclosing Relay.
Motor Coils of Reclosing Relay are Continuously Excited.
When Breaker is Tripped by Over-current Relays bb Finger of No.152 Closes Circuit to Reclosing Relay Which Times and Recloses Breaker Trips a Predetermined Number of Times.
On Severe Over-current No's 186 Lock out the Equipment after Tripping No.152 by No's 151.

FIG. 1. ELEMENTARY WIRING DIAGRAM OF A TYPICAL A.C. RECLOSING FEEDER

At the right of this figure there is given an elementary diagram, which shows to a certain extent how the feeder goes through the various steps in reclosing. The ordinary operating sequence takes place from left to right in this diagram. It will be noted that the coil and various contacts of an individual device may be at opposite ends of a diagram. This is necessary since all parts of a device do not always come into play at the same time during the sequence. Each device is referred to by a number, according to the function which the device performs. These numbers are based on a system which has been standardized by the Electric Power Club and adopted by the General Electric Company. These numbers appear on the front and back of the panel on wiring diagrams and in the instruction books. The object in view being to obtain a system which does not necessarily pay any attention to the type of a device, but concentrates on its function. In the case of a large equipment, it is sometimes found that a given type of device may be used a number of times, but will have a different function for each time it appears. Again, the same function may be performed by a number of different devices.

It is felt that the legend given in Fig. 1 is self-explanatory. In Fig. 2 there is given an assembled back view of some of the principal devices. These assemblies assist in obtaining an approximate idea as to the construction and operation of the particular device. More complete information is found in the instruction book on the particular device. In the following paragraphs there is given a general description of the more common devices used with a.c. reclosing feeders. These

*Switchboard Department, General Electric Co.

devices are taken arbitrarily in order of their function number.

Device No. 101

In Fig. 3 is shown the twin pull button control switch used as Device No. 101. The switch, as shown in this figure, has its various contacts in the same position as shown at the right of Fig. 1. The auxiliary contacts 7-8 are shown in the open position in Fig. 2. These contacts are mechanically connected to the tripping button so that, when this button is operated to trip the breaker, the reclosing relay circuit is opened, and no attempt will be made (on the part of this relay) to reclose the breaker. Contacts 7-8 are closed again by operating the closing button. This operation closes the breaker directly from No. 101 (see Fig. 1). In order to prevent the timer from being unnecessarily released by this closing operation, there has been added to the

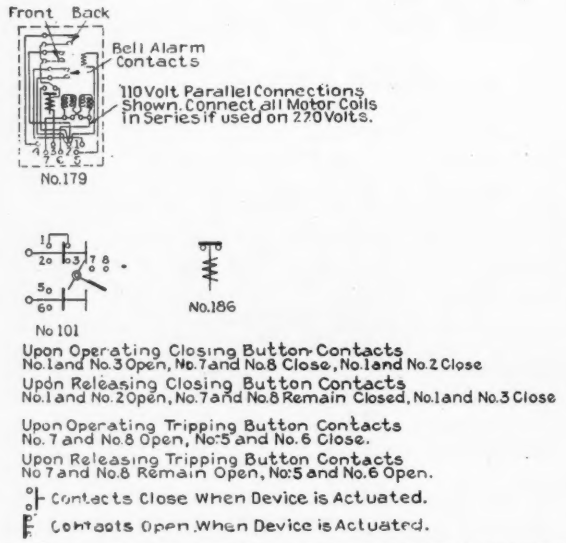

Front Back
Bell Alarm Contacts
110 Volt Parallel Connections Shown. Connect all Motor Coils in Series if used on 220 Volts.
No.179
No.186
No.101
Upon Operating Closing Button Contacts No.1 and No.3 Open, No.7 and No.8 Close, No.1 and No.2 Close
Upon Releasing Closing Button Contacts No.1 and No.2 Open, No.7 and No.8 Remain Closed, No.1 and No.3 Close
Upon Operating Tripping Button Contacts No.7 and No.8 Open, No.5 and No.6 Close.
Upon Releasing Tripping Button Contacts No.7 and No.8 Remain Open, No.5 and No.6 Open.
Contacts Close When Device is Actuated.
Contacts Open When Device is Actuated.

FIG. 2. ASSEMBLIES OF SOME OF THE PRINCIPAL DEVICES USED IN RECLOSING SYSTEMS

closing button shaft a second set of contacts, 1-3, which in series with 7-8 keep the release coil circuit of No. 179 open until the closing button is released. If the closing button is held until the red lamp lights or mechanism is tripped automatically, then contacts 1-3 and 7-8 of No. 101 will give the desired operation. If the closing button is "snapped" before the breaker completely closes, then the release coil of No. 179 is energized long enough to cause the timer to go through an idle cycle of operation. If the breaker remains closed, No. 179 returns to its normal position. If No. 152 opens, it is reclosed by No. 179.

Device No. 108

The control power switch is usually double pole, single throw. Its function is to connect and disconnect the control circuits from the operating bus. The switch used for this purpose is of the knife blade type and, consequently, does not require further description.

Device No. 151

The overcurrent relay is usually of the familiar induction disc type, giving an inverse time-current characteristic. This relay is circuit closing which, in conjunction with the tripping reactors mentioned above, actuates the trip coils of the oil circuit breaker mechanism. Where direct current trip is used, the relay connects the trip coils to the direct current source direct.

Device No. 152

Various types of oil circuit breakers are used as Device No. 152. A mechanism commonly used to operate these breakers is shown in Fig. 4. The mechanism shown in Fig. 4 is used in conjunction with the larger breakers, especially of the large outdoor type. These mechanisms are motor-operated and are available for use on either alternating or direct current. The breaker is closed by the motor and rotating fly-weights which, in effect, act as variable ratio adjusters and result in the motors delivering a closing effort commensurate with that required at the different parts of the breaker closing stroke.

Interrupting Rating

One of the most important features to be considered when applying alternating current reclosing feeders is the interrupting rating of the oil circuit breaker. The operating cycle used with these equipments is usually more severe than the cycle upon which the published value (cycle "b" in the following tabulation) is based. After the short circuit current has been found, and the reclosing cycle determined, the interrupting rating at the "standard operating cycle" or 100 per cent (published) value may be determined.

At times, the interrupting rating for a particular breaker on a certain duty cycle is less than the maximum short-circuit current obtainable. In such cases it is recommended that a single-impulse, locking-out current relay be used. This relay is hand reset and locks out the reclosing equipment if the value of over-current exceeds a predetermined amount.

The following interrupting ratings of oil circuit breakers have been approved by the N. E. L. A. and Electric Power Club, and were also presented in the report of the Committee on Protective Devices at the annual convention of the A. I. E. E., held at White Sulphur Springs, W. Va., during June, 1926:

a. One-unit operating duty.....100% to 125%
   Rating varies between limits given with design of breaker.
b. Two-unit operating duty, two minute interval, (Standard Operating Duty)..... 100%
c. Four-unit operating duty, two minute interval 70%
d. Four-unit operating duty, one-half minute interval 60%
e. Four-unit operating duty, no time intervals.. 25%
f. 300-unit operating duty, 15 minute intervals 30%
g. Four-unit operating duty, successive intervals of 0, 30, 75 seconds..... 30%
h. Four-unit operating duty, successive intervals of 15, 30, 75 seconds..... 40%
i. Three-unit operating duty, one minute intervals 70%

1. With reference to operating duties (d), (e), (g) and (h), while there are no known limitations which prevent the general application of these operating cycles to all oil circuit breakers, still, in view of lack of operat-

ing experience and possible hazard it is recommended that these operating cycles be confined to breakers having interrupting rating on operating cycle (b) of not over 250,000 kv.a., and having voltage ratings of 37,000 and lower.

2. Zero means no-time delay between full open position and start of closing.

3. The present factor which the operators are using for operating duty (e) is 30 per cent, but it is the opinion of the Power Club that 25 per cent is more suitable.

In the above tabulation a unit operating cycle is understood to consist of a closing of the circuit breaker followed immediately by its opening without purposely delayed action.

For circuits of 4000-6600 v. and less, cycle "h" is used more frequently. From 60—80 per cent of the time the breaker remains closed on the first reclosure. As the breaker continues to open on overload, the chances of remaining closed are decreased. In order to lessen the interrupting duty on the breaker the subsequent

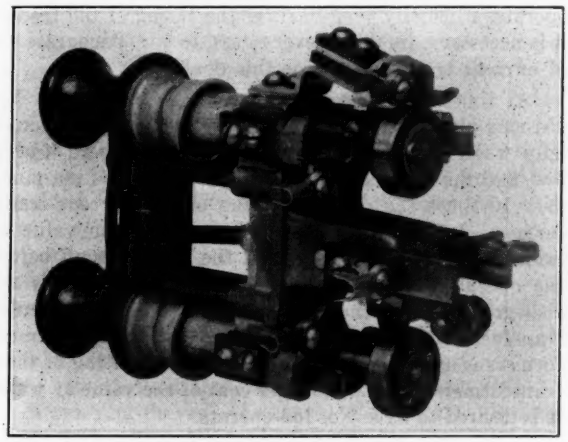


FIG. 3. TWIN PULL BUTTON CONTROL SWITCH SHOWING CLOSING, TRIPPING AND AUXILIARY CONTACTS

intervals are increased. The 15-sec. initial interruption has not been found to be serious for general lighting and residential load. At times it has been found advisable to increase this interval to 30 sec. or greater, in order to allow synchronous motors sufficient time to drop off the line.

Cycles like "e" and "g" have had a limited application. The "0" interval usually results in no time delay action other than that purposely required to make the devices sequence properly. For example, with certain types of breakers the arc in the oil vessel on heavy overloads may extend a greater portion of the opening stroke before interrupted. During this interval the coil of the over-current relay (Fig. 1) is still energized and, obviously, its contacts are still closed. As soon as the breaker has completely opened, it is immediately closed and, if the breaker is of a fast closing type, will reclose its contacts before the overcurrent relay can open its contacts. This results in tripping the breaker even though no overload may be present. As mentioned above, this operation is dependent on a number of factors, such as the type of breaker, time drop-out characteristic of the relay, as against values of over-current, etc. In order to guard against such undesired tripping action, there are added such contacts and devices as will result in the proper sequence.

From results of a large number of tests, it has been found that the so-called "0" interval (as obtained from the present type of closing mechanism) is not short enough to hold in the more common undervoltage release used on induction motor starters. While the oil circuit breaker is open the stored flux in the induction motor rotor gives the effect of a rotating field which is fast decaying. The stator terminal voltage decreases to a value less than the drop-out value of the undervoltage release in less than 0.6 second, where the motor handles a "friction" load. If any flywheel effect is present, this value may be somewhat greater. This result is

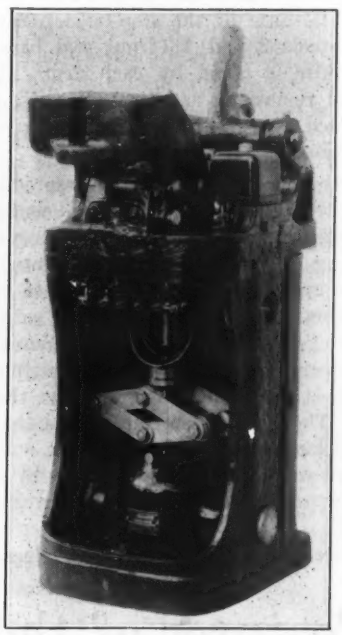


FIG. 4. MOTOR OPERATED MECHANISM USED IN CONJUNCTION WITH THE LARGER CIRCUIT BREAKERS

obtained with no short-circuit or faults on the line. If such conditions are present, then the latter time value is decreased. The resulting operation from equipments designed to give an initial "0" interval, has been that about 50 per cent of the undervoltage releases drop out and the rest remain in. Where tandem or group drive is used, it appears to be better to allow sufficient time for all releases to drop out.

Reclosing relay No. 179 used with the units described in this article is shown in Fig. 4. The internal connections, as well as the connections to associated devices of the reclosing feeder, are shown in Fig. 1. A number of contact arms are fastened to a large gear which, through a suitable reduction, is driven by an induction disc motor. The coils of this motor are permanently connected across the control power bus. These coils draw approximately 0.3 ampere at 220 v., 60 cycles, regardless of whether the disc is rotating or at standstill. The contact arms and rotating mechanism are held in a stationary position by means of an arm which

is attached to the same shaft as the large gear. This arm is in contact with the release stop, which is drawn away by the release coil when the breaker opens. This action permits the timer to rotate. After an interval—depending on the angular setting of the first arm—contacts 2 (Fig. 1) close. This action picks up the auxiliary relay which "seals itself" in around contacts 2 (front contacts). Contacts 2 then open, followed in a short time by the closing of contacts 4 (back contacts). The latter contacts in series with the closed contacts of the auxiliary relay close the oil circuit breaker No. 152.

Closing of No. 152 de-energizes the auxiliary relay which in turn drops out. If the breaker opens again it is closed in a similar manner by the second (and third) contact arms, which are spaced at suitable intervals, in order to give the desired time delay between reclosures. Because of the step-by-step contact action between contacts 2 and 4 (front and back) only one closing impulse is given by each arm. Thus, if the timer should remain in one position, with one of these contacts closed, there is no tendency to give a "pumping" operation.

Whenever No. 152 closes the release coil of No. 179 is de-energized. This coil, however, comes into play only at the start and finish of the timing cycle of No. 179. Having once released the reclosing relay at the start of the cycle, the timer continues to rotate in the same direction by means of its motor coils. Near the end of the cycle there is placed a lockout arm which stops the timer, No. 179, in a locked out position if the release coil is energized, showing that the breaker is still open. The timer is so constructed that it remains in this position even though there is a subsequent loss of control power, and can be reset only by means of the reset button projecting through the cover as shown in Fig. 4.

If the breaker remains closed the release coil of No. 179 is de-energized. The timer passes the lockout position and returns to its normal position, where it is ready for further operation.

The number of reclosures is dependent on the number of contact arms. A total of three are available, two of which are readily removable. Another set of contacts is included to indicate that the timer is in the locked out position.

Device No. 186 is used quite frequently with a.c. reclosing feeders. This relay, as shown graphically in Fig. 1, has a set of circuit opening hand reset contacts, which open on one impulse of the relay plunger. As mentioned above, this relay operates whenever overcurrent has exceeded a predetermined value. The latter value is usually less than 125 per cent of the interrupting rating as determined by the particular duty cycle. In such applications the maximum current obtainable under short circuit conditions should not only be checked against the derated value of the circuit breaker, but also against its 100 per cent rating, in order to make sure that there is a suitable margin.

In view of the fact that the current at which No. 186 operates is usually over 10 times the rating of the feeder, it is necessary, in almost every case, to add a separate set of current transformers for this device.

At times the same transformer used for device No. 151 may also be used with No. 186. Such cases are found only when the connected secondary volt-ampere load is low, and the point at which No. 186 operates is not much over 10 times the primary rating of the current transformer. In most cases, it is found that the value of exciting current is so great that the ratio falls off before the operating point is reached. These limitations are also governed by the characteristics of the particular transformer. Consequently, a separate set of transformers is used for No. 186. The primary rating of these transformers is usually 10 per cent of the value at which it is desired to have No. 186 operate.

Features of the Super-Synchronous Motor

MOTOR HAVING BOTH REVOLVING STATOR AND ROTOR COMBINES IN ONE MACHINE THE GOOD QUALITIES OF THE SYNCHRONOUS AND INDUCTION MOTOR

OF THE VARIOUS types of electric motors used in industries, one of the most interesting, both mechanically and electrically, is the super-synchronous motor used extensively in the cement and milling industries. This motor, developed several years ago by the General Electric Co., is so constructed mechanically that its pull out torque is also its starting torque. While a particularly large number of these motors have found their way into cement plants where their ability to meet the heavy starting requirements and long periods of uninterrupted heavy service, has proved singularly successful, they have many applications in other industries as well.

Based on fundamental principles of design, it is an excellent form of drive for such loads as are typically represented by centrifugal pumps, where bypass connections are omitted, air compressors where unloading valves are omitted, vacuum pumps, mine fans and other large blowers, crushing, grinding and pulverizing machinery in cement mills, rock crushing plants and ore dressing mills, paper pulp feeders, flour mill line shafts, rubber mill line shafts, machines that are characterized by heavy flywheel effects and machines that are difficult to start when stopped, loaded with material.

In the development of the super-synchronous motor, the problem was that of securing a motor that would approach the starting characteristics of the wound rotor induction motor and the running characteristics of the salient pole synchronous motor. In other words, a unit was desired that would start on heavy load but when once started, would operate with high efficiency and at any desired power factor. In considering the various requirements, the salient pole synchronous motor was found to have a number of advantages. It has an air gap approximating twice that of the induction motor; its rotor is of more simple construction and can be repaired more rapidly; it is more stable in operation and, when running, can be made to have a high power factor.

In the super-synchronous motor, therefore, the conventional salient pole synchronous motor as designed for

low starting torque duty was suitably modified to meet two requirements. The first requirement was that the winding must be synchronized while the motor was directly coupled to a stationary load. The second requirement was that the motor, while operating at synchronous speed, must be capable of bringing to that speed the stationary dead load to which it was coupled. The super-synchronous motor as developed, therefore, combines in a simple, compact and efficient unit, the operating characteristics heretofore obtained only by the use of a cumbersome clutch in conjunction with a normal synchronous motor.

In electrical construction and essential dimensions, the super-synchronous motor is identical with the normal synchronous motor of the same rating designed to start without load. This motor differs from the normal synchronous motor in its mechanical features, this difference consisting primarily of the suspension of the armatures (stator) so that it is free to rotate and the addition of a brake to control the rotation of the armature. Suspension of the armature is accomplished by hollow journal extensions on the end shields which are carried by bearings at the inner end of the standards containing the motor shaft bearings. The stator frame is constructed of rolled steel plate fabricated from two halves which are welded together in a solid unit. The welded joints are reinforced by parallel straps which lap the joints and are welded to the plate. The supports for the armature punching are also welded to the plate so that the completed frame has the strength of a unified forging. The supports which carry the punchings also have bolted to them suitable rings to which the windings are secured when speeds are involved which make it necessary to take into account centrifugal force. The field member is of the usual construction and is keyed directly to the shaft. Excitation for the field is obtained in the usual manner through collector rings mounted on the ends of the shaft, but with the leads running through the center of the shaft. Because of the light duty required of the amortisseur winding, this is generally made in sections unit with each pole. The periphery of the armature frame is machined for a braking surface and is fitted with the standard band brake of mine hoist and cable weigh practice. The brake is operated either by a hand lever and quadrant or by an electric solenoid.

When starting, the brake is released. The armature

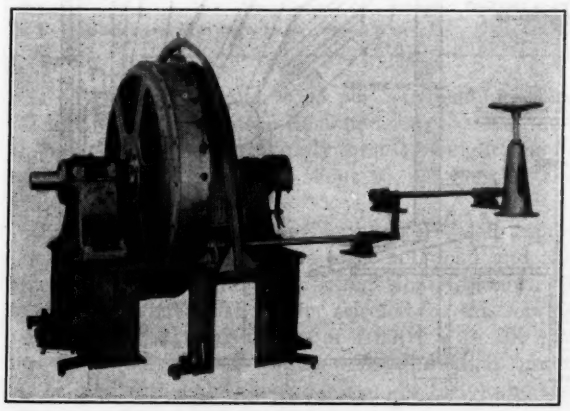


FIG. 1. A 550-V. SUPER-SYNCHRONOUS MOTOR SHOWING ARRANGEMENT OF STATOR BRAKE

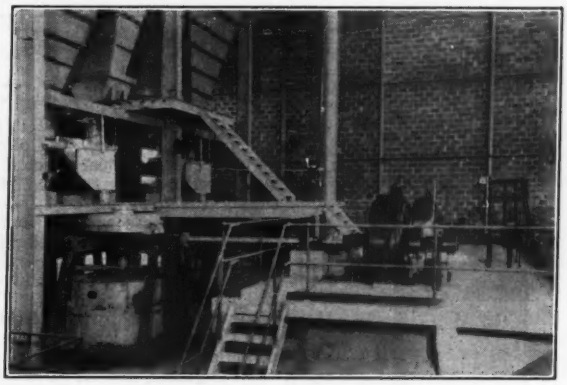


FIG. 2. TWO 300-HP. SUPER-SYNCHRONOUS MOTORS DRIVING BRADLEY-HERCULES MILLS, VIRGINIA PORTLAND CEMENT CORP., NORFOLK, VA.

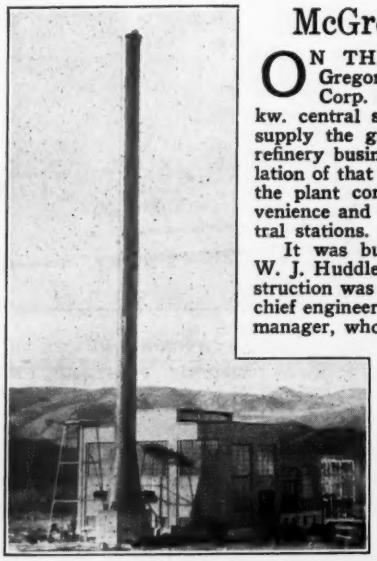
is energized and comes up to induction motor speed. The field is then energized and the armature comes to synchronous speed. The brake is then applied with the result that the armature slows down and the field and attached load speed up. Acceleration of the field and load proceeds to synchronism proportionately as the armature is brought to rest. When the armature becomes stationary, the brake is locked and the unit continues to operate as a normal synchronous motor. Throughout the acceleration of the field from zero to synchronism, the motor is able to deliver a torque of much greater value than at normal full load torque. The current during starting bears the same relation to the full load current as the starting torque required bears to the full load torque. A starting torque of 125 per cent full load torque will draw 125 per cent full load current from the machine.

With regard to the action of the brake it is sufficient to state that the relatively large torque radius at the band makes it a simple matter to provide adequately for the heat and tension requirements.

The super-synchronous motor is particularly fitted for all types and loads where a synchronous motor can be advantageously used and more than 50 per cent full load torque is required before synchronism is reached. The salient features of the super-synchronous motor may be listed as follows:

1. Ease of control, which permits of the starting of high torque loads with a minimum of mechanical stress and electrical disturbance.
2. The starting torque is the full pull out torque.
3. The alinement and maintenance of a clutch and extra bearings are eliminated.
4. The brake and armature are stationary during normal operation. This reduces wear on working parts to a minimum. The inherent characteristics of the brakes are such that greater accuracy of load control during starting or when starting mills is obtained than is possible with a clutch.
5. The design can be made to accentuate the desirable features, particularly size, by disregarding starting torque in the ordinary sense.
6. Simplicity of rotating parts that characterizes the standard synchronous motor.
7. The starting current is low compared with an induction motor for the same starting torque.

McGregor Plant of Colorado Utilities Corporation

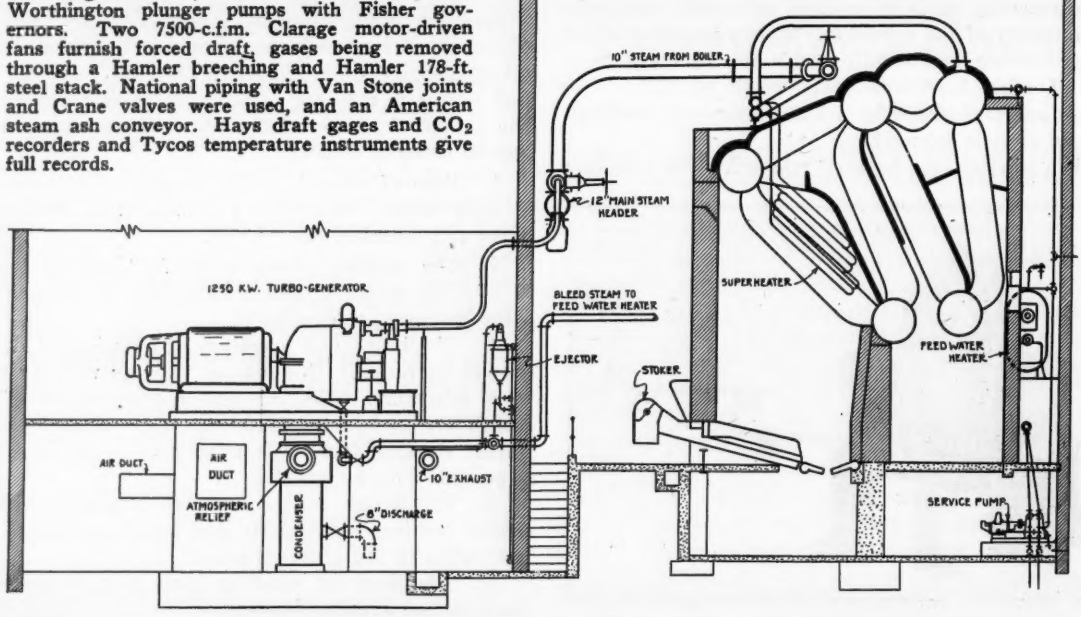


ON THE BEAR RIVER at McGregor, Colo., the Colorado Utilities Corp. has just erected a new 2700-kw. central station, shown at the left, to supply the growing coal industry and oil refinery business and the increasing population of that district. Although it is small, the plant contains every facility for convenience and economy found in larger central stations.

It was built by the Austin Co., with W. J. Huddle as consulting engineer; construction was supervised by G. A. Whitney, chief engineer, and A. E. Anderson, general manager, who are now in charge of it.

Power is generated by a General Electric 1250-kw., 2300-v., 3600-r.p.m. turbo-generator with a C. H. Wheeler jet condenser and a Westinghouse 1500-kw., 2300-v., 3600-r.p.m. turbo-generator with a Westinghouse surface condenser. Biddle and G. E. tachometers, Weston meters, Westinghouse switchboards and switching equipment, G. E. lightning arresters and Condit oil switches are installed.

Steam is generated at 250 lb., 250 deg. superheat by two Casey Hedges boilers, with Elesco superheaters and Westinghouse underfeed stokers, Diamond soot blowers, S-C regulators, Yarway and Everlasting blowoff valves. Water is heated in a Worthington heater, and fed to boilers by two Worthington plunger pumps with Fisher governors. Two 7500-c.f.m. Clarage motor-driven fans furnish forced draft, gases being removed through a Hamler breeching and Hamler 178-ft. steel stack. National piping with Van Stone joints and Crane valves were used, and an American steam ash conveyor. Hays draft gages and CO_2 recorders and Tycos temperature instruments give full records.



Power Consumption of Flour Mills

THERE IS A DECIDED ADVANTAGE IN THE USE OF ELECTRIC MOTORS DRIVING EACH MACHINE INDIVIDUALLY. BY GROVER C. MEYER*

MILLING involves four distinct operations which constitute the process or system. They are cleaning or otherwise preparing the grain for grinding, the grinding operation, bolting or sifting and the purification of the product. Power consumption in the various departments may be divided roughly as shown in Table I.

As the several milling operations of the modern mill are inter-dependent, the mill must operate as a unit.

TABLE I. POWER CONSUMPTION IN A FLOUR MILL IS DIVIDED BETWEEN DEPARTMENTS AS INDICATED

Grinding rolls	40	per cent
Separating or bolting sifters, reels, purifiers and dusters	14	" "
Packers, exhaust fans, etc.	13	" "
Grain cleaning machinery, including receiving apparatus	16	" "
Elevators and shafting	17	" "

This, however, does not mean that the mill must receive its power from a single driving unit as it did in former years when steam and water were the only sources of power. By referring to Table II, it is seen that the ratio of kilowatt demand to capacity of the mill in barrels varies between 0.262 and 0.346 with an average value of 0.308. This value varies with the grain storage capacity which also has a material effect upon the load factor. The load factor may vary between 0.85 and 0.95 with the yearly average based on 720 hr. operation per month as high as 0.68, while the power factor will range

TABLE II. STORAGE CAPACITY HAS A MATERIAL EFFECT ON THE UNIT KW-HR. DEMAND

Mill Bbl.	Capacity Elevator Bushel Storage	Kw. Demand	R.	Kw. Yearly	Production on Yearly Bbl. of Flour	KWH per Bbl.
3000	675,000	864	.288	4,212,419	585,058	7.2
500	150,000	155	.310	465,520	68,459	6.8
1700	300,000	587	.345	1,739,200	214,716	8.1
1600	400,000	535	.334	2,883,960	424,112	6.8
1200	220,000	362	.302	1,073,884	145,119	7.4
1400	225,000	403	.288	2,040,960	309,263	6.6
6200	2,000,000	2016	.325	11,178,744	1,415,030	7.9
480	80,000	126	.262	429,064	52,971	8.1
500	80,000	144	.288	428,000	50,952	8.4
1200	350,000	357	.297	1,713,600	272,000	6.3
3500	1,200,000	1209	.345	5,986,000	893,433	6.7

R. Ratio of Kw. Demand to capacity in Bbl. Average R .308

from 63 per cent lagging to 95 per cent leading. The mill load when once on the line operating is steady and the load curves vary but slightly from a straight line as the friction load represents about 65 per cent of the total.

Grinding rolls, bolters, purifiers and elevators represent about 75 per cent of the total mill load and are driven as a single unit constituting what is known as the main mill drive. The motor selected for this service should have a starting torque of from 200 to 300 per cent of their full load torque. The induction motor may be used, although it has a poor power factor and the synchronous motor offers a decided advantage, especially from the standpoint of the public utility.

Equipment in the cleaning department is usually driven in groups and represents from 11 to 16 per cent of the total mill load. No special motor characteristics are required in this division, and many mills have taken advantage of the load as a means of power factor correction and have installed synchronous motors. Auxiliary equipment, such as flour packers, conveyors, wrapping machines and fans for the dust collection systems are usually individual drive with motors of the squirrel cage induction type. Conveyors, car pullers, elevators

TABLE III. DATA ON SEVEN INDIVIDUAL MILLS BRINGS OUT THE DIFFERENT MOTOR ARRANGEMENTS

Mill No. 1	
Capacity	1,050 Bbl. per 24 Hr.
Yield	4-22
Wheat milled - equal parts of Hard Spring - Hard Winter - Red Winter and Western White	
Moisture content at first break	15%
Bbls. Cap. per hp. const.	3.34
Hp. hr. per bbl. of flour	7.19
Kw. hr. per bbl. of flour	5.36
No. 1 motor, hp.	47.17
No. 2 motor, hp.	7.55
No. 3 motor, hp.	9.81
No. 4 motor, hp.	231.55
No. 5 motor, hp.	6.92
No. 6 motor, hp.	11.45
	314.45
Mill No. 2	
Capacity	950 lb. per 24 Hr.
Yield	4-24
Wheat Milled	Kansas Hard
Moisture Content at first break	15.4%
Bbl. capacity per hp. const.	3.25
Hp-hr. per bbl. of flour	7.39
Kw-hr. per bbl. of flour	5.51
Total hp. used	292.54
Mill No. 3	
Capacity	1,050 bbl. per 24 Hr.
Yield	4-23
Wheat milled	Kansas Hard
Moisture content at first break	15%
Bbl. capacity per hp. constant	3.45
Hp-hr. per bbl. of flour	6.99
Kw-hr. per bbl. of flour	5.22
Total power used	306.04
Mill No. 4	
Capacity	1,704 bbl. per 24 Hr.
Yield	4-18
Wheat milled - 50% Turk Scft and 50% Aus. White	
Moisture Content at first break	12.33
Bbl. capacity per hp.	3.48
Hp-hr. per bbl. of flour	6.89
Kw-hr. per bbl. of flour	5.14
Total Hp. used	489.2
Percent of total hp. used for cleaning	11.14%
Mill No. 5	
Capacity	1,600 Bbl. per 24 hr.
Yield	4-21
Wheat milled	Nebraska Avg. Mixture
Moisture content at first break	14.5%
Bbl. of cap. per hp.	3.66
Hp-hr. per bbl. of flour	6.54
Kw-hr. per bbl. of flour	4.98
No. 1 motor, hp.	95
No. 2 motor, hp.	106
No. 3 motor, hp.	119
No. 4 motor, hp.	69.7
No. 5 motor, hp.	40.4
No. 6 motor, hp.	7.5
	436.6

Mill No. 6	Hd. Sprg.	Ks. Hd.	Ind. Soft
Wheat milled			
Bbl. cap. per 24 hr.	2000	2000	2000
Yield	4-27	4-23	4.26
Moisture cont. at 1st break	14.5	14.5	14.5%
Bbl. cap. per Hp.	3.46	3.59	3.72
Hp-hr. per bbl. of flour	6.94	6.69	6.45
Kw-hr. per bbl. of flour	5.18	4.99	4.81
No. 1 motor delivering, hp.	77.4	77.4	77.4
No. 2 motor delivering, hp.	93.3	93.1	92.9
No. 3 motor delivering, hp.	93.4	93.2	92.9
No. 4 motor delivering, hp.	92.9	82.2	72.0
No. 5 motor delivering, hp.	90.3	80.8	71.4
No. 6 motor delivering, hp.	118.9	118.9	118.9
No. 7 motor delivering, hp.	12.03	12.03	12.03
Total hp. used	578.23	578.23	578.23
Percent of total hp. used for cleaning	13.4	13.9	14.4

Mill No. 7	Hd. Sprg.	Ks. Hd.	Ind. Soft
Wheat milled			
Bbl. cap. per 24 hr.	1200	1224	1248
Yield	4-25	4-22	4-20
Moisture cont. at first break	12-3/4%	12%	13¼
Bbl. cap. per hp. const.	2.94	3.21	3.51
Hp-hr. per bbl. of flour	8.16	7.71	7.25
Hp. for cleaning	45.0	44.1	43.0
Hp. for milling	363.0	349.2	334.0
Total hp. used	408.0	393.3	377.0
Percent of total hp. used for cleaning	11.03%	11.21%	11.40%

and such equipment in the elevator and grain storage are usually driven by single and double winding squirrel cage motors on account of dust explosion and high insurance rates. The former are used where a high starting torque is not essential and the latter where considerable torque is required to start when the equipment is fully loaded, for instance, because of an interruption of power.

Power data on various mills are given in Table III without going into detailed information on the function of each machine. Flour mills range in capacity from 25 to 17,000 bbl. per day and require from 6 to 11 kw-hr. to manufacture a barrel of flour. The number of electrically driven mills is constantly increasing as electricity is without question the ideal mill drive.

OF THE TOTAL cost of a piping installation, 80 per cent will consist of fabrication, valves, fittings and labor, the remaining 20 per cent being the cost of the pipe itself. Many pipe lines are subject to corrosion such as boiler feed, drips, drains, blowoff, exhaust, saturated steam, hot water and cooling water lines. The purchase of cheap pipe for these purposes will save approximately 5 per cent of the installation cost. The result will be shorter life, higher upkeep, more frequent repairs and interruptions of service, all of which are costly. It pays to buy good pipe in the first place.

*Industrial Engineer, Kansas City Power & Lt. Company—from a paper delivered before the A. I. E. E. at Kansas City.

Results of Efficiency Tests at Wilson Dam

METHODS OF CONDUCTING EXTENSIVE TESTS ON INITIAL UNITS, EMPLOYING BOTH THE WEIR AND GIBSON METHODS, WITH COMMENTS ON THE RESULTS OBTAINED. BY L. B. FEAGIN*

EFFICIENCY TESTS, conducted at Wilson Dam by the government through the Hugh L. Cooper Co. from October, 1925, to February, 1926, were probably the most comprehensive and complete field tests ever made on a hydro-electric power plant. As the tests occurred near the completion of construction, a large and excellent personnel was available, which added accuracy and thoroughness. An appropriation was made available, which permitted far more extensive investigations than would have been made in a privately owned plant.

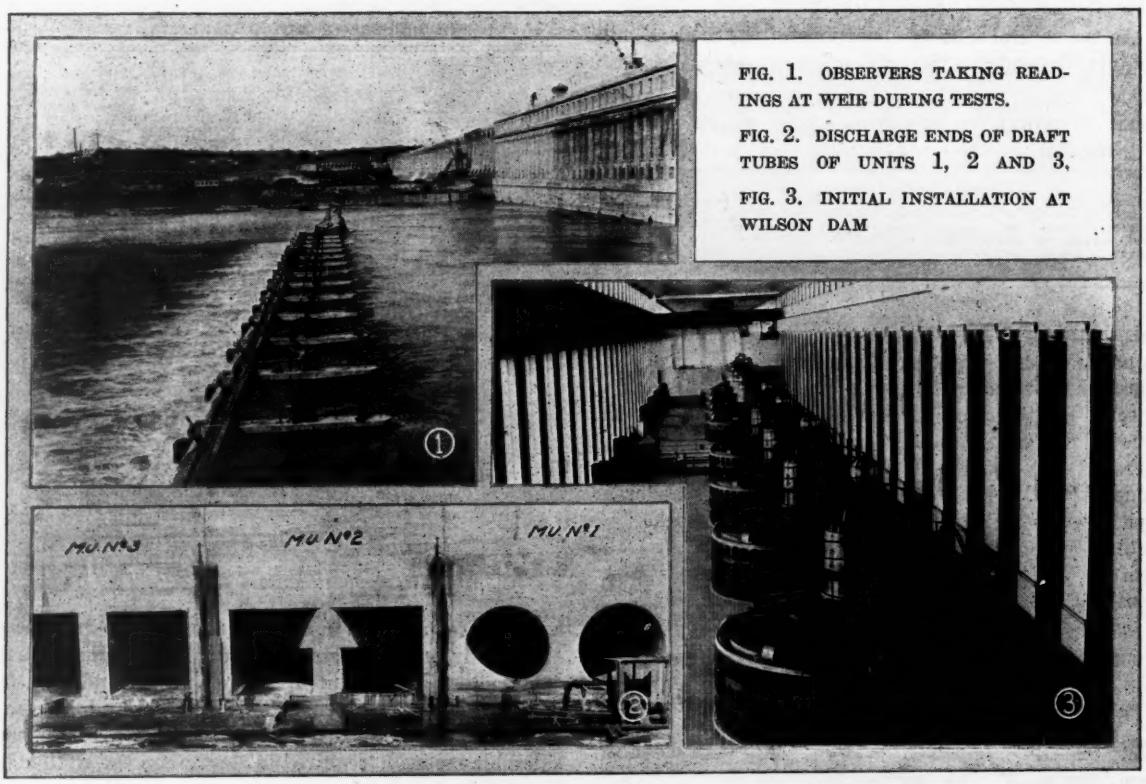


FIG. 1. OBSERVERS TAKING READINGS AT WEIR DURING TESTS.

FIG. 2. DISCHARGE ENDS OF DRAFT TUBES OF UNITS 1, 2 AND 3.

FIG. 3. INITIAL INSTALLATION AT WILSON DAM

The purpose of the tests was to obtain accurate information in regard to the performance characteristics of hydraulic and generating equipment, which carried a high efficiency guarantee with a penalty bonus clause, and second, to obtain information which might be of value to the engineering profession.

The present installation, Fig. 3, consists of 4 Westinghouse-I. P. Morris units of 30,000 hp. rated capacity each, and 4 General Electric-Newport News units of 35,000 hp. rated capacity each. Provision is made for the installation of 10 additional units in the future, which will increase the present rated capacity to 610,000 hp.

Each unit is fed by three concrete penstocks of approximately 194 sq. ft. cross-sectional area each. The draft tubes of all main units are concrete and, with the exception of No. 1, are of the Moody spreading type with central cone, while No. 1 has a draft tube of special bifurcated quarter turn design.

In making efficiency tests of hydro-electric units, it is necessary to know the power output of the turbine or generator, the head, either net, or gross, under which the unit is being tested, and the quantity of water flowing through the turbine. The output in the tests at Wilson Dam was determined by means of ammeters, voltmeters, and wattmeters for generator and exciter. The head was determined by means of staff and hook gages and a piezometer, the gross head being the difference in elevation of forebay and tailwater and the net head being found by deducting the head lost in friction in the penstocks and in residual velocity at exit from the draft tubes. The quantity of water was determined by the weir and the Gibson methods.

It was originally intended to use only the weir in testing and it was accordingly specified in the Newport News turbine contract. It was later found, however, that except for a considerable change in the construction schedule, main units Nos. 5 to 8 would not be ready for testing until the season of high water at which time the weir would be drowned out. Any flow greater than 20,000 c.f.s. in the north channel over the spillways and 3000 c.f.s. over the weir would submerge it.

Accordingly, the consulting engineer on July 25, 1925, recommended the employment of Norman R. Gib-

*Junior Engineer, U. S. Engineer Department.

son, chief hydraulic engineer, of the Niagara Falls Power Co., to run a test on units Nos. 4 and 8 by his method and apparatus. The idea was that tests on unit No. 4 should be run both by the weir and by Mr. Gibson's method. If Mr. Gibson's results checked with the results obtained by the weir, then his method would be considered accurate and further tests could be run with his apparatus at any stage of the river, and the weir could be abandoned and removed.

Testing Weir Constructed with Great Care

The weir used in these tests, Figs. 1 and 4, was the largest ever constructed, the total being 500 ft. long and consisting of 15 weir compartments 30 ft. long with 3-ft. intermediate piers containing stilling wells and hook gages. The crest was formed by a sharp-edged steel plate held in place by a 6-in. by 6-in. by 5/8-in. angle. Every precaution was taken to insure precision in the construction of the weir and in the alinement of the crest.

In the weir tests, however, it was apparent that the flow through the 15 compartments was not uniform. When the test on No. 4 was run, three or four compartments in the center of the weir showed flow at right angles to the crest. The compartments on one side of those in the center each showed a marked eddy and those on the other side showed a similar eddy but in the opposite direction. This was due to its being so close to the draft tubes that flow could not be straightened out before reaching the weir.

In the test of unit No. 1 this condition was aggravated due to the fact that this unit is directly upstream from the south end of the weir and the water from its wheel therefore had to flow diagonally with respect to the crests to reach practically all weir compartments. The results obtained from the weir test on unit No. 1 may therefore be questioned as to accuracy.

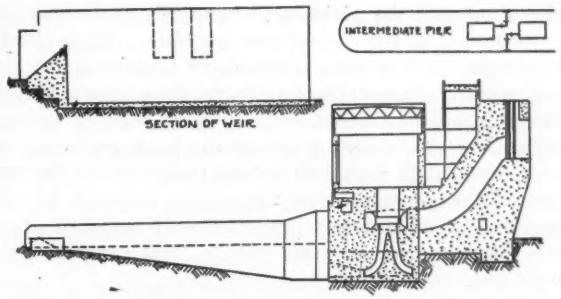


FIG. 4. DETAILS OF CONSTRUCTION OF MEASURING WEIR FOR TESTING WILSON DAM TURBINES

Much interest was centered about No. 1 due to the special design of its draft tube, Figs. 2 and 5, which was entirely different from that of the other units; accordingly a test by the Gibson method was also made of that unit.

The apparatus used in testing by the Gibson method, with details of the method of use, were described fully by Mr. Gibson on page 469 of the April 15, 1927 issue of Power Plant Engineering.

The generator of the unit being tested was syn-

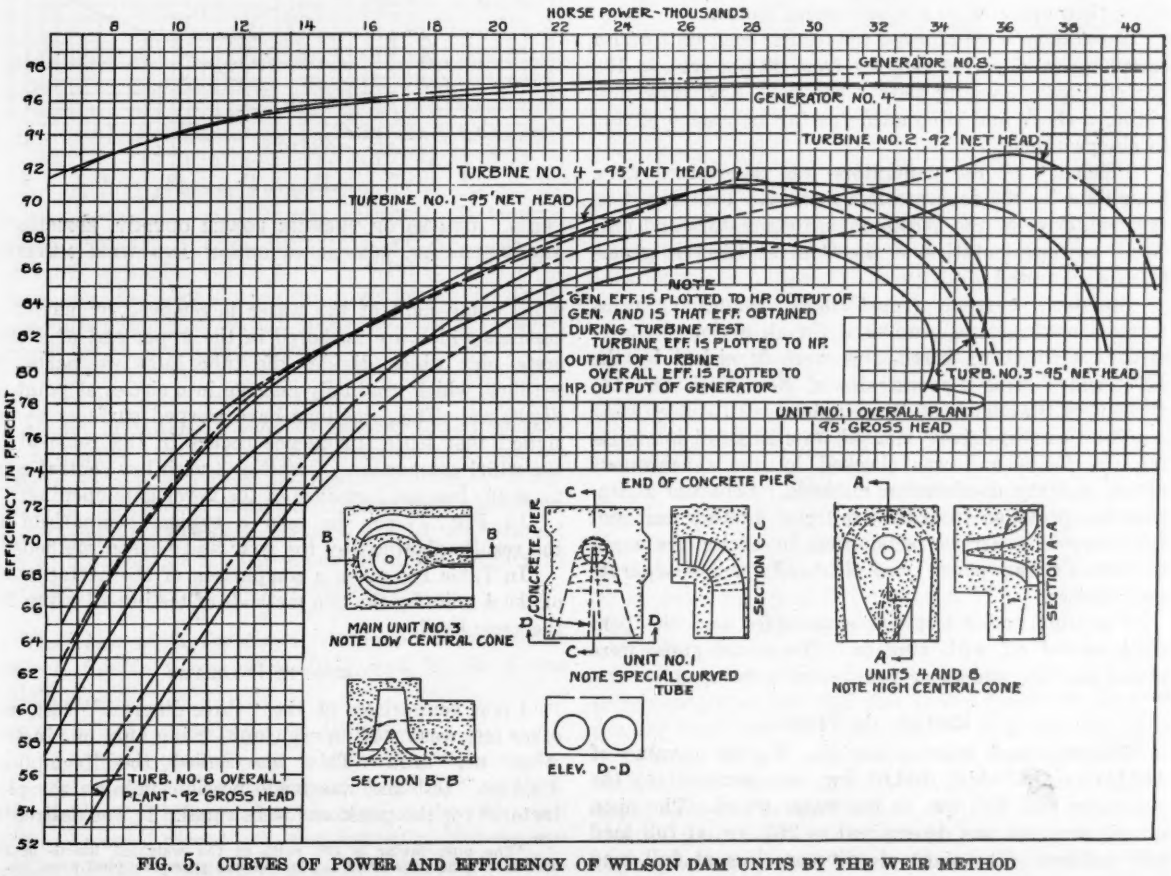

HORSE POWER-THOUSANDS
8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
EFFICIENCY IN PERCENT
98 96 94 92 90 88 86 84 82 80 78 76 74 72 70 68 66 64 62 60 58 56 54 52
GENERATOR NO.8
GENERATOR NO. 4
TURBINE NO. 2 - 92' NET HEAD
TURBINE NO. 4 - 95' NET HEAD
TURBINE NO. 1 - 95' NET HEAD
NOTE
GEN. EFF. IS PLOTTED TO HP. OUTPUT OF GEN. AND IS THAT EFF. OBTAINED DURING TURBINE TEST
TURBINE EFF. IS PLOTTED TO HP. OUTPUT OF TURBINE
OVERALL EFF. IS PLOTTED TO HP. OUTPUT OF GENERATOR.
TURB. NO. 3 - 95' NET HEAD
UNIT NO. 1 OVERALL PLANT 95' GROSS HEAD
TURB. NO. 8 OVERALL PLANT - 92' GROSS HEAD
END OF CONCRETE PIER
CONCRETE PIER
SECTION C-C
SECTION A-A
MAIN UNIT NO. 3 NOTE LOW CENTRAL CONE
UNIT NO. 1 NOTE SPECIAL CURVED TUBE
UNITS 4 AND 8 NOTE HIGH CENTRAL CONE
SECTION B-B
ELEV. D-D

FIG. 5. CURVES OF POWER AND EFFICIENCY OF WILSON DAM UNITS BY THE WEIR METHOD

chronized with the Alabama Power Co.'s system and the governor set at the desired gate opening. When steady conditions of flow were attained, at a prearranged signal, readings were taken for ten minutes, at one minute intervals, of the forebay level by hook gage, of the tail water level by a staff gage, of the hook gages on the weir, and of all electrical meters to determine the output of the generator and the power required for the exciter, which is direct connected and mounted above the generator on the same shaft. This completed the weir test.

Next, 5 readings were taken at 30-sec. intervals similar to those of the weir test with the exception that hook gage readings on the weir were omitted.

Immediately following the last reading, the governor man, using the hand control, closed the turbine gates while the Gibson apparatus made a pressure-time

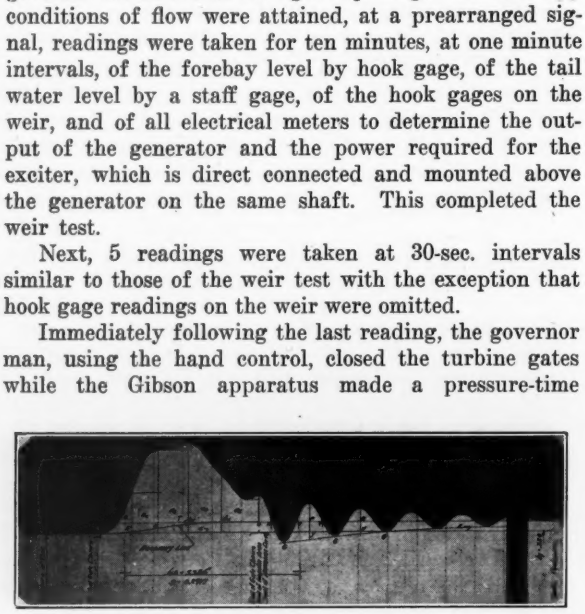


FIG. 6. TYPICAL DIFFERENTIAL PRESSURE-TIME DIAGRAM OBTAINED WITH GIBSON APPARATUS

diagram, Fig. 6. Complete closure was made in from 2 to 8 sec., depending on the gate opening.

The generator continued to revolve at normal speed, being then operated as a synchronous motor.

Three days were allowed for testing each unit and a complete set of points ranging from 20 per cent to 100 per cent gate opening were taken each day, thus providing a check and eliminating as far as possible errors in observations.

Efficiency of the generators was determined at a later date by the separate loss method. Unit No. 4 as representative of the Westinghouse generators and unit No. 8 as representative of the General Electric generators were tested.

Standard current transformers, potential transformers, and meters, were used for all major measurements. Calibration certificates were furnished by the Electrical Testing Laboratories of New York and the Bureau of Standards of Washington.

The "exciter-drive" method was used for determining the losses and was checked by the synchronous motor and the deceleration methods. Separate excitation was provided from the exciter of another unit and from motor generator sets, used to excite the main exciter; driving power was obtained from a separate unit exciter.

The unit under test was stop-logged and the penstock sealed off with cinders. The wheel gates were closed and the generator ventilators were open.

Results of Tests

Windage and friction for No. 4 gave a value of 147.11 kw. of which 106.61 kw. was assigned to the generator and 40.5 kw. to the water wheel. The open circuit core loss was determined as 267. kw. at full load and voltage. The short circuit core loss at full load current was 149.5 kw. The armature I^2 R loss at full load and 75 deg. C. was 142.68 kw., while the field I^2 R loss for the same conditions was 145.23.

For No. 8 the water wheel was disconnected from the shaft, and the test made by the exciter drive method. The losses for this unit were windage and friction 111.16 kw., open circuit core loss 271 kw., short circuit core loss 97.8 kw., armature I^2 R loss 160 kw., and field I^2 R loss at 80 per cent p.f., 119 kw.

In Fig. 5 may be seen the turbine efficiency curves for units 1, 3, 4, and 8 by the weir method, the overall efficiency of No. 1 at 95 ft. gross head and the overall efficiency of No. 8 at 92 ft. gross head which was the head specified for the acceptance test. Efficiencies of the generators of units No. 4 and No. 8 are also given.

It may be observed that there is a rather sharp rise in the turbine efficiency curves of units No. 4 and No. 8 near the points of maximum efficiency. This is attributed to the fact that these two units have the same type draft tube with the high central cone.

Unit No. 1 appears to have the most creditable performance curve over the widest range of gate openings. This type tube was designed by B. H. Parsons, Chief Engineer, of the Hugh L. Cooper Co. Much of the

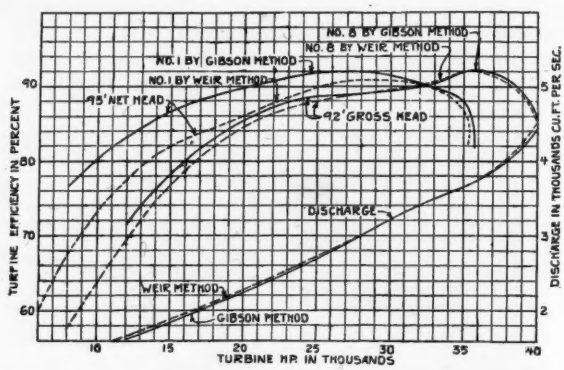


FIG. 7. CURVES OF TURBINE POWER OUTPUT, EFFICIENCY AND DISCHARGE, COMPARING GIBSON AND WEIR METHODS

whirl component of the water is removed by partition castings which are anchored in the upper end of a concrete pier which divides the tube into two parts, or sections, which gradually enlarge into circles at point of discharge. These castings have warped surfaces so designed that little turbulence occurs in the removal of the whirl component. Unit No. 3 with low central cone gives the best performance at the lower gate openings.

In Fig. 7 may be seen a typical comparison of the results obtained by the weir and Gibson methods.

In Table I is given a comparison of the performance of the 4 units by the two methods of testing all given for the same head.

Composite Diagrams

Upon completion of the "three-diagram" test, another test was made on each unit, using only one instrument per unit. This was called the "composite diagram" test and was made possible because the pipe factors* for the penstocks were equal. It was desired to

*The pipe factor is the ratio of the weighted length of the section of pipe considered to the average cross sectional area.

make the composite tests to determine whether one instrument could be used for future tests of the plant and also as an approximate check on the other work. The "three diagram" tests, however, were the criterion for rating.

For the test of No. 4, the first unit tested, the three upper piezometers were interconnected by means of a ¾-in. header. Likewise the three lower piezometers were interconnected by a ¾-in. header.

The U-tube of the Gibson apparatus was then connected to the two headers at points near the center piezometer connection. With this piping the two methods of testing gave results which differed by about 1 per cent along the discharge curve, the composite diagrams giving the smaller discharges.

For the test of units No. 1 and No. 8, the piezometer headers were made of 1½-in. pipe, instead of ¾-in. pipe, and each header was tapped at two points and connected through a ¾-in. header to the Gibson apparatus. This arrangement was considered preferable should there be a marked difference in the flow distribution among the three penstocks.

TABLE I. COMPARISON OF PERFORMANCE OF MAIN UNITS 1, 3, 4 AND 8, BY THE GIBSON AND WEIR METHODS

Unit No.	Method of Test	Net Head	Max. Unit Eff. (Turbine & Gen.)	MAX. TURBINE EFFICIENCY				MAX. OUTPUT OF UNIT		
				Max. Eff.	Turbine Output H.P.	Discn. c.f.s.	Gate Opening	Eff. %	Power H.P.	Discn.
1.	Gibson	95'	89.4	92.1	27500	2770	56.5	79.4	24780	4060
	Weir	95'	88.2	91.04	29609	3252	61.9	78.6	32290	3814
3.	Weir	95'	88.12	90.94	27766	2834	57.0	77.99	32400	4086
4.	Gibson	95'	89.0	91.8	27000	2730	57.0	77.3	34600	4160
	Weir	95'	88.43	91.23	27205	2768	55.1	78.17	32800	4119
8.	Gibson	95'	91.3	93.2	38100	3784	72.5	83.3	42300	4705
	Weir	95'	90.82	92.76	38500	3848	73.7	82.89	41230	4700

In Table II is given a comparison of discharges by the two methods at various gate openings. It may be noticed that the average difference for No. 1 is 0.4 per cent, while for No. 8 it is + 0.4 per cent. For future efficiency tests during the operation of the plant, the results obtained with one apparatus should be satisfactory for all practical purposes.

Loss of Head

A plot of lost head versus discharge indicated that the hydraulic losses of penstock friction and residual velocity head at exit from the draft tube varied as the square of the velocity, since the curve method plotted on logarithmic cross section paper was parallel to a straight line with a slope of 2. The exponent of the velocity V, therefore, is equal to 2 in the equation:

$$h_f + h_r = kv^2$$

The value of K for No. 1 was found to be 0.0239, while K for No. 4 was only 0.0173, and for No. 8 was 0.0183.

Comparative Costs

It is difficult to arrive at a basis for comparing the actual costs of the weir and Gibson tests at Wilson Dam. The two tests were carried on simultaneously and much of the personnel served in a dual capacity. For the operation of the turbine and generator, reading of electrical meters, and of head water and tail water elevations and determination of losses in the penstock, the same personnel was used.

Three men were required to operate the Gibson apparatus itself, except when the composite diagrams were made, at which time only one operator was required, and one man for changing films in the dark room. On the weir 15 men were required for reading the hook gages and one man for giving the signals for readings.

Preparation for the Gibson tests cost approximately $2000, while construction of the weir cost $43,478, exclusive of overhead, which amounted to approximately $20,000. Rental of the Gibson apparatus for all the tests cost $7200. Removal after the tests were completed required less than a day at a negligible cost. Removal of the weir was economically possible only when a sufficient stage of the river for dredging prevailed, which was some months later, during which time there was a loss of approximately 4 ft. head. The cost of removal was approximately $5000 to date. The total cost of the tests including personnel and overhead for both methods was approximately $150,000.

TABLE II. COMPARISON OF 3-DIAGRAM AND COMPOSITE DIAGRAM METHODS

Gate Opening % Piston Stroke	Discharge C.F.S. 3 Diagrams	Composite	Difference C.F.S.	%
Main Unit No. 1				
40	1900	1900	0	0.0
50	2430	2410	—20	—0.8
60	2890	2870	—20	—0.7
70	3270	3250	—20	—0.6
80	3590	3565	—25	—0.7
90	3850	3845	—5	—0.1
100	4060	4050	—10	—0.2
			Average.....	—0.4
Main Unit No. 8				
40	1950	1950	0	0.0
50	2480	2480	0	0.0
60	3020	3020	0	0.0
70	3540	3550	+10	+0.3
80	3960	4000	+40	+1.0
90	4290	4330	+40	+0.9
100	4575	4600	+25	+0.5
			Average.....	+0.4

Undoubtedly the Gibson method is the more accurate of the two methods and is certainly more economical than the weir. The personnel required is less and the time required for testing less. Tests by the Gibson method are independent of seasonal floods, which drown out the weir.

As was stated before, the weir was specified in the contract with the turbine manufacturers; accordingly, bonuses were paid based on the weir test. For units 5 to 8, inclusive, the guaranteed maximum efficiency at 92 ft. gross head was 90.5 per cent. That attained was 92.05 per cent. The excess, therefore, was 1.55 per cent, which for four units at a premium of $3500 for each per cent excess efficiency amounted to $21,700. The power output at full load was approximately 6 per cent greater than that indicated by the Holyoke test on a homologous runner. Units No. 1 to 4 also exceeded their turbine performance guarantees, but had no penalty bonus clause in the contract.

The tests were carried out in accordance with the testing code approved by the Machinery Builders' Society, October 11, 1917.

Where One Boiler Serves Entire Textile Plant

PLANT OF THE NORWICH KNITTING MILLS AT NORWICH, N. Y., OPERATES ENTIRE MILL FROM ONE PULVERIZED COAL FIRED BOILER

PLACING THE RESPONSIBILITY for the running of an entire power plant, in fact, an entire mill, upon a single boiler would, ordinarily, not be considered good practice, but with the modern equipment installed at the plant of the Norwich Knitting Mills at Norwich, N. Y., the practice has resulted in no serious trouble. Entire dependence for the operation of this plant is placed on one 400-hp. water tube boiler fired by pulverized coal. True there is still one old hand-fired boiler installed which, in case of emergency, might carry a small portion of the load, but this is so inadequate that it can in no way be considered reserve capacity. This small boiler is used when the mill is not in operation and for purposes of starting up.

Until the first part of this year this plant operated on two hand-fired boilers, furnishing steam to the mill and also to an engine for electric generating purposes. During recent years, however, the mill has been enlarged considerably and the management was confronted with the problem of providing additional steam generating capacity. Space in the boiler room was limited and in order to provide the maximum boiler capacity in the minimum space, at the same time having flexibility of control in mind, it was decided upon to install a pulverized coal fired boiler.

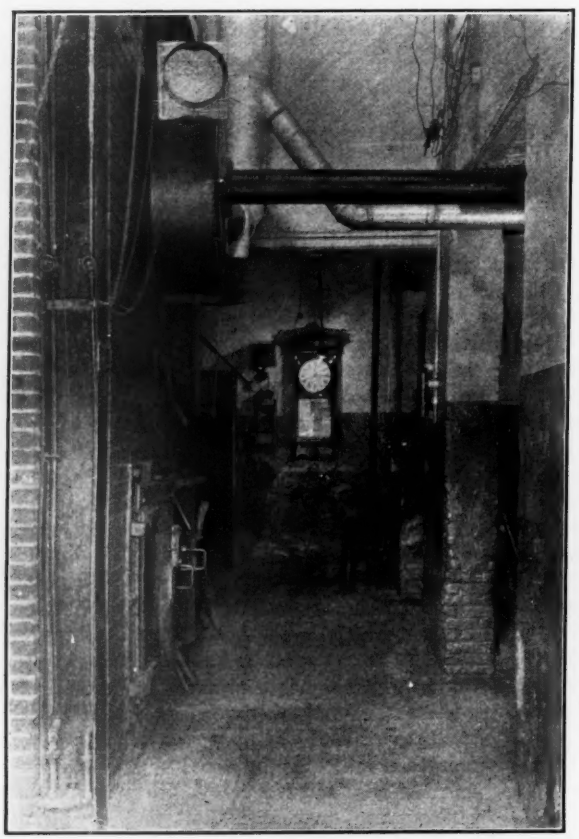


FIG. 1. THE LINE FROM THE PULVERIZER FEEDS DIRECTLY INTO THE FRONT WALL OF THE FURNACE

The new boiler is a 400-hp., vertical, four-drum, water-tube unit, equipped with a superheater and fired by a unit pulverized coal system. Steam is generated at a pressure of 125 lb. with superheat to give a total temperature of 480 deg. Normally this boiler is operated at about 200 per cent of its rated capacity.

Pulverized coal was selected not only because it would enable the boiler to be operated at high ratings, continuously, but also because of the ability of a pulverized coal system to respond to sudden changes in load. A textile mill is extremely erratic in its demand for steam. At a particular time all the dye vats may be off the line; an instant later all of them may be turned on, with a resulting sudden demand on the boilers for large quantities of steam. Again, as suddenly as the steam to the vats is turned on, it may be shut off. Naturally, in order to take care of a load of this kind properly the boiler must be capable of quick response.

During the short time that this equipment has been in operation, this ability to conform to sudden load changes has been demonstrated to the satisfaction of everybody concerned. There have been, of course, the usual minor difficulties met with in the starting up of any new plant, but no trouble of a serious nature has occurred.

The arrangement of equipment is extremely simple. The coal pulverizer is located immediately in front of the boiler with the feeder running horizontally into the furnace as shown in Fig. 1. Primary air for combustion is drawn underneath the furnace floor where it is heated and is then passed through the pulverizer, thus drying the coal somewhat. Raw coal is delivered to the pulverizer hopper directly from an overhead storage silo. The coal handling and storage arrangement possesses several features of interest.

COAL STORED IN TWO SETS OF SILOS

Incoming coal is stored in two cement slab silos, each having about 135 t. capacity and located adjacent to a railroad siding a short distance away from the boiler house. A track hopper is provided through which the coal is delivered to a bucket conveyor and carried to the tops of the storage silos.

At the boiler house, two other cement silos are provided. These are located directly above that half of the boiler room containing the pulverizing equipment so that coal may flow by gravity through an opening in the bottom of the silo directly to the coal pulverizer below. Coal is transferred from the storage silos near the railroad siding to the silos above the boiler room by truck. At the boiler room the truck delivers to a bucket elevator which elevates the coal to the top of the silos and finally a horizontal flight conveyor running over the tops of the silos delivers the coal into the silos.

FINE COAL SEPARATED FROM COARSE COAL

In connection with this coal handling system an interesting arrangement is provided to separate coarse coal from the fine coal, the former being used for hand firing under the old boiler and the latter being sent to

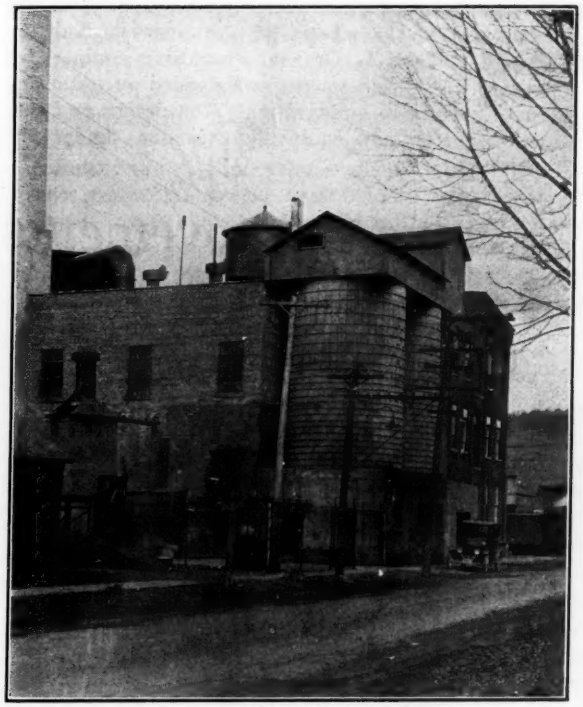


FIG. 2. EXTERIOR VIEW OF THE PLANT SHOWING THE COAL STORAGE SILOS DIRECTLY ABOVE THE FORWARD PART OF THE BOILER ROOM

the pulverizer. Just above the opening in the top of the first silo, a number of steel slats are set up on edge in the manner shown in the illustration, so that the fine coal, as it is carried along by the flight conveyor falls between the slats into the silo. The coarse coal cannot pass between the slats and is carried to the next silo which is provided with a single large opening.

The coal pulverizer is installed in the boiler room as previously mentioned in front of the boiler immediately below the "fine" coal silo. A spout fitted with a mechanical coal meter leads from the bottom of this silo to the hopper of the pulverizer.

The pulverizer is equipped with the dual system of drive, a 25-hp. steam turbine being attached to one end of the driving shaft, and a 25-hp. induction motor to the other end. Normally, the machine is motor driven but when starting up and when the main engine is not in operation the turbine is used. When starting up the turbine receives steam from the small hand-fired boiler. The pulverizer is equipped with a magnetic separator to remove tramp iron in the raw coal. This separator is supplied with direct current by a small d.c. generator

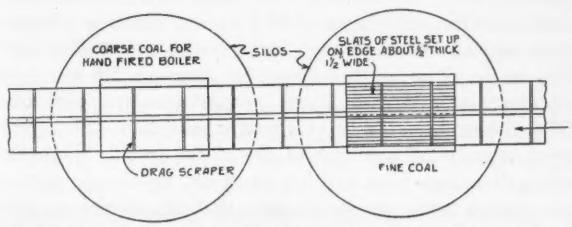


FIG. 3. ARRANGEMENT FOR SEPARATING AND STORING THE COARSE AND FINE COAL

mounted on the frame of the pulverizer and geared to the main shaft.

Although a small plant, everything has been installed with the object of obtaining high economy and at the same time reliability. Being almost entirely dependent upon the continuous operation of a single boiler, every effort has been made to prevent forced shutdown. Since one of the most important factors in boiler operation is freedom from internal scale, a zeolite water softening apparatus is provided which not only softens water for the boiler but that used in the textile mill as well. Water for all purposes is obtained from wells. It is pumped by four triplex pumps, through the zeolite softener into a roof tank. From the roof tank it flows by gravity into the open feed water heater from which the feed pumps take suction and deliver it to the boilers.

Steam is supplied to the mill for process work and to a 320-hp. uniflow engine driving a 200-kw., 200-r.p.m., 60-cycle, 220/110-v. generator. This machine supplies all the electric energy used in the mill and since it operates non-condensing, over half of all the steam used is for drying. The entire mill is heated by exhaust steam.

From the foregoing, it will be obvious that the entire plant arrangement has been kept as simple as possible—one boiler, one burner, one pulverizer and an extremely simple coal handling arrangement. Instruments are provided to check operation, among which are included a multiple pointer draft gage, measuring secondary air pressure, furnace draft and uptake pressure; a boiler meter, a CO_2 recorder and a flow meter measuring the steam supplied to the dye house. Barring failure of the boiler itself, the only thing that could force a shutdown

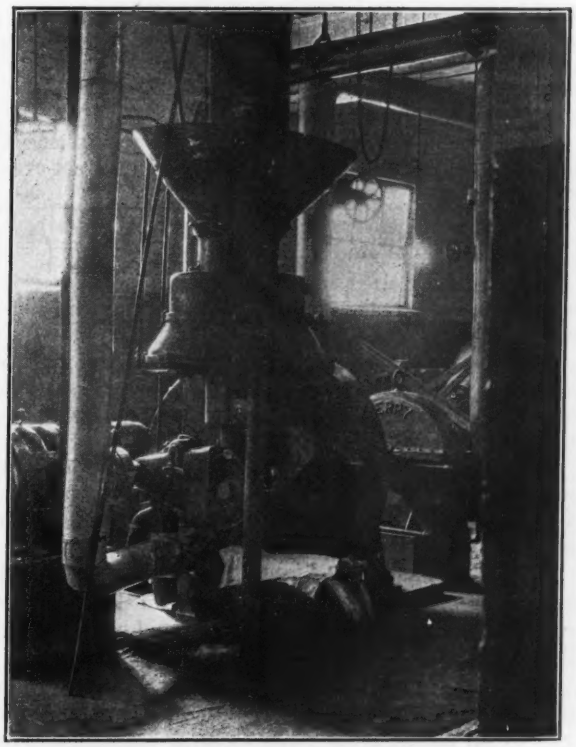


FIG. 4. A VIEW OF THE PULVERIZER

is failure of the pulverizer or its driving member. Since a dual drive is provided, the chance for shutdown from failure of the driving members is remote, leaving the pulverizer itself, perhaps, the most vulnerable point in the system. Spare parts of the pulverizer are kept on hand, however, so that a broken or worn out part could be quickly replaced if necessary.

In concluding this article, we wish to express our indebtedness to the officers of the Norwich Knitting Mills and to John L. Graham, consulting engineer, of Syracuse, N. Y., for courtesies extended in gathering material used in its preparation. The design and construction of the new equipment was done under Mr. Graham's direction.

Ammonia Compressor and Valve Improvements

FACTORS RESPONSIBLE FOR ECONOMY IN COMPRESSORS. RELATIVE MERITS OF DIFFERENT TYPES OF VALVES DISCUSSED AT MEETING OF THE N. A. P. R. E. IN NEW YORK

IMPROVEMENTS IN AMMONIA compressors and valves were discussed at a recent meeting of New York Chapter No. 2 of the National Association of Practical Refrigerating Engineers in New York by J. H. H. Voss. By means of 35 lantern slides, Mr. Voss analyzed the action in a gas or air compressor together with the design and proportions required to give high compressor efficiency. Like that of other operating men, the task of the practical refrigerating engineer is not always an easy one, said Mr. Voss. The refrigerating engineer is expected to get the most out of a plant regardless of its layout, detail or design.

In order to obtain the best results at the lowest cost, it is necessary to be well informed regarding every detail of the plant. The efficiency of ammonia compression refrigerating machines is influenced by so many factors that it is desirable for the practical engineer to be guided by well established rules. The efficient operation of a plant depends on the design of its apparatus, on the operating temperatures, on maintenance and the skill of the operator.

FEATURES CONDUCIVE TO ECONOMY

Experience shows clearly the importance of facilitating the work of the ammonia gas or liquid by all the means known to the refrigerating engineer. This, according to Mr. Voss, required:

a. In main suction and discharge pipes a gas speed not exceeding 5000 ft. per min.; in liquid pipes, not over 200 ft. per min.

b. No sharp elbows or tees in pipe lines; use bent pipes and oversize stop valves.

c. Use good sized insulation on low pressure side apparatus and storage rooms and all low pressure pipe lines.

d. Use large heat transmitting surfaces both on the low and high pressure sides. Heat transmits most efficiently in apparatus with large surfaces and small inside volume.

e. Run the ammonia compressor dry but do not suction superheat the gas before it enters the compressor. The suction side white frosted and the discharge hot is a good rule to follow.

f. Do not pump liquid with the compressor; install a liquid separator near the compressor on the low pressure side and pump the accumulated liquid back into the liquid receiver or into the expansion coils.

g. Watch the relative position of the apparatus; place the low pressure side below the liquid receiver and by all means avoid goose necks in the high or low pressure liquid or main piping.

h. Do not place condensers and liquid receiver in the hot engine room.

i. Precool the liquid just before the expansion valve, using the coolest water available.

k. See that the system is cleaned out regularly, keep a written record of the oil input and withdrawal so you know where the oil goes. To protect the compressor use a suction scale trap.

l. See that the compressor piston rings and especially the valves are tight and that the valve springs are not too strong nor too light.

m. Use pure ammonia; test it and keep the system free from foreign gases.

IMPORTANCE OF CORRECT VALVES

Particular attention should be paid to the ammonia compressor valves. Small or badly designed valves prevent the easy flow of the ammonia gas through the compressor. Small valves cause high gas speed with excessive heating and as hot gas does not carry as much capacity per cubic foot as cold gas, the plant efficiency is needlessly reduced. Heavy valves are slow moving, and while they may have an apparently large area, they are too sluggish to make this area effective. The final result is the same as if the valves were too small, the ammonia gas is heated and churned uselessly.

The first test in which some of these points have been brought to the attention of the refrigerating engineers were made at the Eastman Kodak Works in Rochester, New York, in 1908. The cylinders used in these tests included a pair of vertical double acting 11¼ in. by 22 in. and a pair of 15 by 22-in. vertical single acting compressors of competing makes.

It may be recalled that at that time the single acting non-clearance ammonia compressor was highly praised for its efficient operation and emphasis was always put on the fact that the better results obtained with the single acting machine were due to its non-clearance feature. This, however, is not the case as can readily be demonstrated.

In these tests the single acting non-clearance compressor, with a cylinder 15 in. diam. and 22-in. stroke, had a suction valve area of 10.4 sq. in., which is 5.88 per cent of the piston area. The main suction pipe was 3½ in. in diam. with 9.89 sq. in. area, or 5.5 per cent of the piston area. These proportions are generous. The discharge valve in this compressor had 4.56 sq. in. area or only 2.6 per cent of the piston area. While the main discharge pipe had 3½ in. diam. or 5.5 per cent of the piston area, we see at once that the discharge area is too small in proportion to the area of the main discharge pipe.

The double-acting compressor, 11¼ in. diam. and 22 in. stroke, had a suction valve area of 2.4 sq. in., which is only 2.44 per cent of the piston area. This proportion is unsound because its percentage of the piston area is considerably less than half the percentage of the suction valve area of the 15-in. single-acting machine and naturally the 11¼-in. cylinder simply could not be filled with gas of the proper pressure and temperature corresponding to the gage pressure in the expansion coils. It is hard to understand why this small suction valve area was put into the 11¼-in. double-acting machine and all the more so because this compressor has a main suction pipe which, in proportion to that of the 15 in. diam. machine is only a trifle smaller, thus proving conclusively that the deficiency in capacity of the 11¼-in. double-acting machine is due solely to the very small suction area.

On the discharge side of the two machines we come to a reversal of conditions. The 11¼-in. diam. double-acting compressor has four discharge valves with a total area of 4.8 sq. in. or 4.88 per cent of the piston area which in percentage is nearly twice that of the discharge valve area of the 15-in. single-acting machine.

The conclusions to be drawn from this comparison of the valve and main pipe connection areas are that the 15-in. cylinder shows small resistances on the suction side, and the 11¼-in. diam. cylinder large resistances on the suction side. On the discharge side the resistances of the 15-in. diam. cylinder are too large, while on the 11¼-in. cylinder the resistances are normal.

Indicator Cards Reveal Defects

This diagnosis is well confirmed in a comparison of the indicator cards taken from these machines at the time of the tests. Under ordinary conditions, that is with unground or badly fitted valves, the 11¼-in. double-acting compressor worked inefficiently and wasted power. With a suction pressure of 28 lb. gage in the brine cooler, the pressure inside of the compressor cylinder was only 18 lb. gage, which meant a loss of 10 lb. of cylinder excess pressure due to small suction valve area and badly fitted suction valves. Improved working conditions with the same area after the valves had been ground and put in A-1 condition showed the loss of the suction to be only 4½ lb., but even this is too high.

The loss in cylinder suction pressure of the 15-in. machine is small, it amounts to about 1½ to 2 lb. at the end of the suction stroke. This is normal under fair operating conditions and is due to the large suction valve area. At the discharge side the 11¼ by 22-in. machine shows only 2 lb. of excess cylinder pressure while the 15-in. machine shows 11 lb. This difference is due only to the great difference in the discharge valve areas of the two machines, the 15-in. cylinder having only 2.66 per cent of the piston area while the double-acting cylinder has 4.88 per cent discharge valve area.

While 20 yr. ago the findings of the Rochester test were very important to the industry, they were not surprising to an expert designer of compressor valves. Mr. Voss stated he discussed these tests at great length because they clearly show the importance of correct valve and compressor cylinder design.

For ammonia compressors, a good rule to follow is to give the suction valves a minimum effective opening of 7 per cent and a maximum of 9 per cent of the piston area; and to give the discharge valves a minimum effective opening of 5 per cent and a maximum of 7 per cent of the piston area. The minimum figures to be used for slow speed machines working with high back pressures and low head pressures; the maximum figures to be used for machines working with low back pressures and high head pressures. In this connection it is interesting to point out the fact that the multiple valve safety heads for single-acting compressors were first made after the Rochester test which conclusively proves that the discharge valve area of the single-acting compressor used in these tests was not large enough in the test machine.

In 1912 the high speed ammonia compressor using light plate valves made its appearance. Great changes have resulted in the ice making and refrigerating industry since the advent of the high speed compressor. After the first compressor had demonstrated the possibilities of high speed, many different types of high speed compressors and plate valves were developed. The light plate valve is ideally adapted for high speed because it can easily follow the quick reciprocations of the piston and throw open a large area instantly. The simplicity of the design of the high speed plate valve and its small resistance to the flow of gas have made it adaptable not only for high speed machines but also for old type slow speed compressors.

In such cases, Mr. Voss stated, a saving of from 10 to 20 per cent in the horsepower required per ton of refrigeration would be obtained.

In concluding his talk, Mr. Voss exhibited various valves and valve parts and finally presented details of a recently patented two-stage compressor. This compressor has a differential piston and gas intercooler, the speed of a 5 by 3-in. unit being 860 r.p.m. This design is intended to obtain large capacity in a compact machine, to take advantage of the two-stage economy otherwise obtained only in large machines, and to lower the price.

Some forms of heavy machinery, such as rolling mills, are driven through gear sets running continuously in an oil bath. The oil for such baths must be carefully selected so that it will not separate and form heavy deposits in the gear teeth, and oil that is suitable for the gear teeth will be found too heavy for journals.

An interesting practice is sometimes pursued in naval machinery to enable both the herringbone gear teeth and bearings to be lubricated with the same oil. A suitable oil cooling system is employed to cool the oil sent to the gears and leave it heated to a certain degree for use in the bearings. If the proper oil and suitable cooling system for given application are employed, the difference in oil temperatures between the cooled and uncooled oil will so affect the viscosity to make them respectively suitable for the gears and the bearings.

Experimental work conducted by the Bureau of Mines indicates that for use in automotive equipment, lubricating oils need not be refined to as high a degree as for use in turbines and similar machinery, and that considerable saving may be made in oil refining processes.

Operation of the Holtwood Steam Station

EXPERIENCE WITH 20,000-KW. PLANT DESIGNED FOR CLOSE CO-ORDINATION WITH HYDRO PLANT. BY F. A. ALLNER*

HOLTWOOD STEAM PLANT is located in Lancaster County, Pa., on the Susquehanna River, about 24 mi. above tidewater, adjacent to and closely co-ordinated with the 111,000-kw. hydro-electric plant of the Pennsylvania Water & Power Co. Through the latter company's customers it is a part of a hydro-steam system including Baltimore, Md., and Lancaster, York, and Coatesville, Pa., with a total installed generator capacity of about 370,000 kw. and with high-tension connections to two other large systems. It is a pulverized fuel burning station, containing at present two 10,000-kw. generators and three 1400-hp. boilers. The plant is laid out for an ultimate capacity of at least 120,000 kw.

The station went into operation in July, 1925. The paper gives the reasons for building a steam plant at Holtwood, some of them being general advantages in such a location for a plant, which is supplementary to a run-of-river hydro-electric plant, and others being the particular advantage in this instance. In general, during the low-flow period, the steam plant carries the base load or belt generation, and during high flow, when the hydro-electric plant is operated at maximum capacity whenever the load permits, the steam plant carries the peaks. This station was especially planned to suit such conditions of operation and was designed for mechanical sturdiness, reliability of service, quick starting, ability to float in at no load and for maximum co-ordination with the hydro-electric plant rather than for maximum economy or minimum first cost.

SPECIAL FEATURES

A number of special features incorporated to carry out this aim are described in the paper, among them

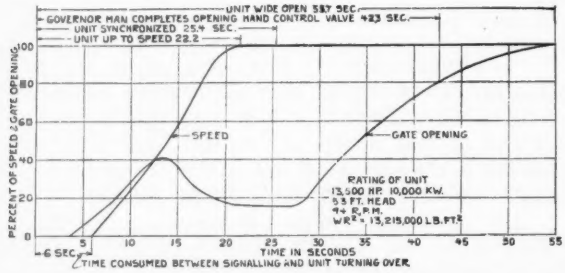

UNIT WIDE OPEN 58Y SEC.
GOVERNOR MAN COMPLETES OPENING HAND CONTROL VALVE 423 SEC.
UNIT SYNCHRONIZED 25.4 SEC.
UNIT UP TO SPEED 22.2
PERCENT OF SPEED & GATE OPENING
SPEED
GATE OPENING
RATING OF UNIT
13,500 HP. 10,000 KW.
53 FT. HEAD
94 R.P.M.
WR² = 13,215,000 LB.FT²
6 SEC.
TIME IN SECONDS
TIME CONSUMED BETWEEN SIGNALLING AND UNIT TURNING OVER

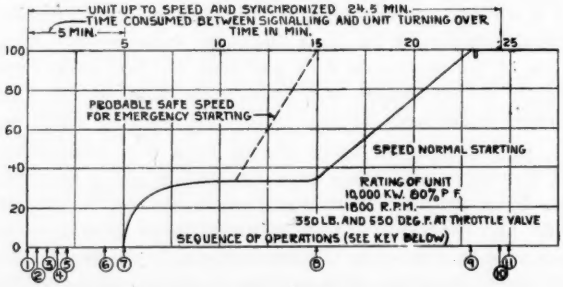
FIG. 1. ANALYSIS OF STARTING TIME OF A 10,000-KW. HYDRO-ELECTRIC UNIT AT HOLTWOOD

being arrangements to facilitate quick starting and floating in, and a special governor so constructed that the speed regulation may be changed by remote control while the unit is running. A comparative analysis of starting times of hydro-electric and steam units at Holtwood is given in Figs. 1 and 2, showing that in spite of special design, the steam unit required a much longer time than the hydro-electric unit.

Pulverized fuel was adopted to secure better sustained efficiency over a wide range of boiler rating, to reduce banking losses, and because it was desired to burn bituminous coal of various grades in the same furnaces with river bottom anthracite coal which is dredged from the upper end of the pond formed by the Holtwood dam. Maintenance costs of the pulverizing plant when burning 100 per cent anthracite are very high.

CHOICE OF SITE

The forebay of the hydro-electric plant, which is protected from floating ice and debris by a rock fill ramp, skimmer wall and floating booms, offered an ideal


UNIT UP TO SPEED AND SYNCHRONIZED 24.5 MIN.
TIME CONSUMED BETWEEN SIGNALLING AND UNIT TURNING OVER
5 MIN.
TIME IN MIN.
PROBABLE SAFE SPEED FOR EMERGENCY STARTING
SPEED NORMAL STARTING
RATING OF UNIT
10,000 KW. 80% P.F.
1800 R.P.M.
350 LB. AND 550 DEG. F. AT THROTTLE VALVE
SEQUENCE OF OPERATIONS (SEE KEY BELOW)

NO.	OPERATIONS BY ENGINEER	CONDENSERMAN	OILER	SWBD. OPERATOR
1	SIGNALS TO CONDENSER RM. TO START			SIGNALS TO ENG'R.
	CONDENSATE & CIRC. WATER PUMPS			
2	CLOSES TURB. DRAINS & TURNS WATER	STARTS CONDENSATE PUMPS	OPENS VALVE TO	
	AND STEAM ON SHAFT SEALS		AUX. STEAM LINE	
3	STARTS STEAM JET AIR PUMP	CIRCULATES CONDENSATE TO TANKS		
4	STARTS AUXILIARY OIL PUMP	STARTS CIRCULATING PUMP		
5	TURNS STEAM INTO TURBINE MAIN			
6	VENTS CONDEN. WATER BOX AND			
	SYPHONS WATER INTO TAIL PIPE			
7	OPENS THROTTLE V.E BRINGS TURB TO 1/2 SPEED			
8	BRINGS TURBINE TO SPEED AND PUTS			
	WATER ON SHAFT SEAL, SIGNALS SW'BD.			
	TO CLOSE GEN. FIELD CIRC. BREAKER			
9	TRIPS TURB. BY OIL TRIP AND REOPENS			
	THROTTLE VALVE			
10				
11	ADJUSTS SEAL LEAKOFF TURNS WATER	TURNS CONDENSATE INTO SUCTION		SYNCHRONIZES GEN.
	ON AIR AND OIL COOLERS	HEADER OF BOILER FEED PUMP		

FIG. 2. ANALYSIS OF STARTING TIME OF 10,000-KW. STEAM UNIT AT HOLTWOOD

source for circulating water. The exact location of the steam plant, however, presented an interesting problem. The site finally selected for the initial section of the power house was immediately below (i. e., on the downstream side) and abutting on the wing wall from the river shore to the hydro-electric plant. Circulating water for the condensers is taken from the forebay and returned to the gate house of the hydro-electric plant, the tunnels having been cut through the wing wall.

Perhaps the greatest advantage of the site selected was the greater amount of space available. Another advantage of the layout adopted is that the injection of warm condenser discharge into the end of the gate house is of value in reducing the chances of capacity reductions caused by frazil ice on the hydro-electric units at that end of the power house.

CENTRALIZED CONTROL

Electrically speaking, the steam plant is essentially a part of the 60-cycle section of the hydro-electric plant. The steam generator leads are carried through a cable duct to oil switches located in the hydro-electric plant switchroom. The control panels for the steam units are

*General superintendent, Pennsylvania Water & Power Co., Baltimore, Md. From a paper presented at the Convention of the A. I. E. E., June 20-24.

a part of the 60-cycle switchboard in the hydro-electric plant. The Tirrill element and the controls for the Keilholtz-Ricketts booster regulator used on the steam units are located on this switchboard.

The desire to facilitate quick starting was the chief reason for limiting the superheat in the initial installa-

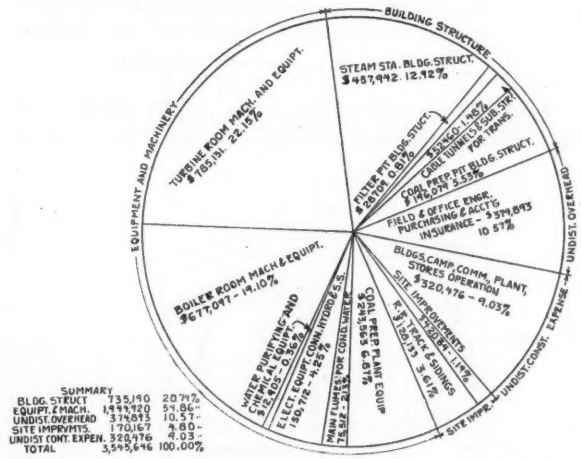

BUILDING STRUCTURE
STEAM STA. BLDG. STRUCT. $487,942. 12.92%
FILTER PLT BLDG. STRUCT. & DITCH 0.81%
CABLE TUNNEL & SUB. STR. FOR TRANS. 1.48%
COAL PREP. PLT BLDG. STRUCT. $146,079. 3.59%
FIELD & OFFICE ENGR. PURCHASING & ACCTG. INSURANCE - $379,893 10.57%
BLDGS, CAMP, COMM. PLANT, STORES OPERATION $320,476 - 9.03%
SITE IMPROVEMENTS $ 4.81%
R.R. TRACK & SIDINGS $ 3.61%
COAL PREP PLANT EQUIP. $ 6.81%
MAIN TUNNEL FOR CONVEYORS $ 2.33%
WATER PURIFYING AND CHEMICAL EQUIPMENT $ 0.36%
ELECT. EQUIP. COMM. HYDRO & S.S. $ 4.25%
BOILER ROOM MACH & EQUIPT. $677,047 - 19.10%
TURBINE ROOM MACH. AND EQUIPT. $ 785,131. 22.15%
EQUIPMENT AND MACHINERY
UNDIST. OVERHEAD
UNDIST. CONST. EXPENSE
SITE IMPR.
SUMMARY
BLDG. STRUCT. 735,190 20.7%
EQUIPT. & MACH. 1,999,920 56.8%
UNDIST. OVERHEAD 374,893 10.57
SITE IMPRVMTS. 170,167 4.80
UNDIST CONT. EXPEN. 320,476 4.03
TOTAL 3,595,646 100.00%

FIG. 3. ANALYSIS OF CONSTRUCTION COSTS OF HOLTWOOD STEAM PLANT

tion to a total temperature of 550 deg. at the throttle. In future extensions it is planned to install larger units, using the first two for quick starting purposes. At that time radiant type superheaters may be installed, giving a total steam temperature of 725 deg. Various schemes have been proposed for maintaining the quick starting feature on the first units, if and when this step is taken, such as omitting the radiant superheater in one boiler, use of a Ruths accumulator, etc.

Average economy for 1926 was 21,160 B.t.u. per net kw-hr. The best weekly economy reported was 18,350 B.t.u. per net kw-hr. burning 100 per cent bituminous; the best weekly economy burning 100 per cent anthracite was 19,800 B.t.u. per net kw-hr. The average boiler and furnace efficiency for the year was 79.6 per cent, without allowance for drier fuel or for energy requirements of the boiler auxiliaries.

Up to date, roughly one-third of all the coal burned has been river anthracite. In a few periods aggregating about 10 weeks, 100 per cent anthracite has been burned. At certain other times, the fuel was all bituminous. Between these two extremes various mixtures were tried out.

A mixture of two kinds of coal is obtained by drawing bituminous and anthracite respectively from the two raw coal bunkers simultaneously upon the drag conveyor which discharges the coal into the dryer where it becomes thoroughly mixed. There has been no trouble due to separation of the two kinds of coal in the dryer, conveyor, mills or transport system. A 50-50 mixture has been found entirely satisfactory for high-flow, fluctuating-load operation.

Outage of Units

The excellent outage record of the Holtwood steam units shows that to a great extent the desire for maximum service reliability has been met. In about 21 months of operation of two units, the total outage due to breakdowns or repairs of mechanical or electrical trouble has been 390 hours or 1.26 per cent of the total unit hours in the period. This time could have been considerably reduced if necessary.

On account of the unusual operating requirements as to loading, fuel supply, etc., the design and operation of this plant involved a number of interesting problems in design and operation, for the solution of which only a limited amount of experience was available. It is believed that nearly all of the major problems have been solved satisfactorily, but there is still need for further experimentation to secure the best possible results from the equipment installed. Figure 3 gives an analysis of construction costs.

Instrument Selection Should Receive Attention

Increasing Application of Instruments and New Applications Give Increased Importance to This Subject

ACTIVITIES of the boiler and turbine room instrument committee of the N. E. L. A. for the past year have been largely confined to an investigation of boiler water indicators, the use of strip versus circular charts for recording instruments and the accuracy of flow meters.

Information from fourteen member companies shows in general that only direct sight of boiler water glasses or indirect sight through mirrors is trusted for feed water regulation purposes. Though hydraulic and electric level indicators have been found accurate and apparently reliable by some companies, they are not trusted. Failure of electric current is considered a possible danger by one, while another reported inaccuracy due to pressure leaks in an hydraulic instrument. The design of periscope used successfully on a high pressure boiler at the Lakeside Station in Milwaukee is shown in Fig. 1. One of these systems with enclosed mirrors has been used exclusively for feed water control since the boiler was put into service.

The basic principle of the method consists of using the water meniscus as a mirror. When illuminated from about 30 deg. below the horizontal and viewed at an equal angle on the opposite side, the meniscus appears as a bright band of light against a dark background. The gage glass assembly is shown right side up and the bright band of light designating the position of the meniscus contracts and expands with slight variations of the water level. Two 200-w. lamps are used to illuminate the glass, penerating through two ¾ in. thick plates of glass and sheets of protecting mica. Satisfactory indications are obtained with a 50-w. lamp held back of the glass in the usual manner at 35 ft. distance when mirrors are so dirty that levels can scarcely be distinguishable at close range.

Another company reports the necessity of lighting

gage glasses from below the meniscus so that it is seen as a bright band of light at a great distance. The special long filament lamps used by some companies to illuminate the entire length of the gage glass are thus undesirable if the meniscus is to be used as a mirror.

Strip and Circular Charts

In general, no particular preference is reported between circular and strip charts. Circular charts are being used for general purposes, whereas the strip charts are used where greater accuracy and legibility are desired. Several report that their electrical departments use the strip chart, bringing up the point that most strip chart instruments are of the electrical type.

The great variety of chart types still existent prompts a further request that instrument manufacturers supply charts of greater similarity. The present charts have time scales forward and backward, and the ordinates arranged in every possible manner which cause confusion and danger of error that can only be eliminated by the use of standardized types. Users of instruments will undoubtedly tend to standardize toward

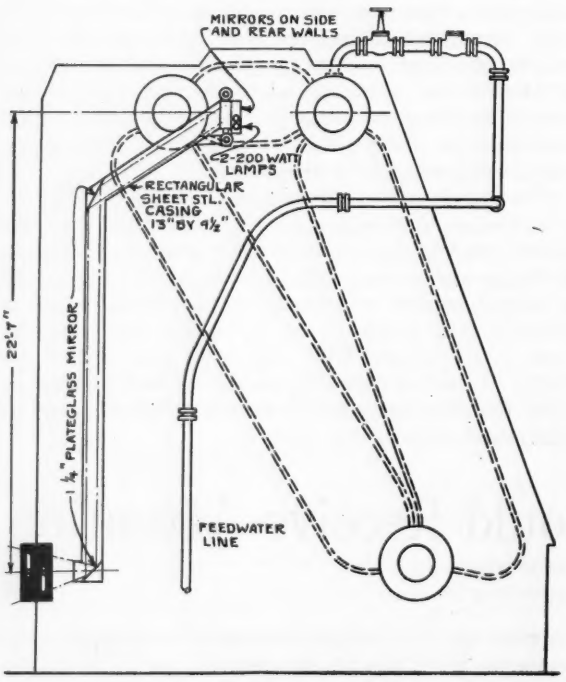


FIG. 1. WATER GAGE GLASS PERISCOPE AS USED IN THE LAKESIDE STATION

easily read charts, but assistance from manufacturers would be mutually beneficial.

Averaging Temperatures with Thermocouples

Connection of any number of thermocouples in series with the cold junctions between each thermocouple at a common temperature allows the automatic determination of average temperatures. This feature which is in actual use at some stations overcomes the objection to strip-chart electrical instruments which apparently limited their usage to non-averaging temperature indicators. Figure 2 shows three thermocouples connected for the purpose of indicating or recording the average temperature in a duct. With the connections shown average temperature is calculated for test purposes as follows: Where M.V. = Millivoltage read on instrument, m.v. = Millivoltage of one cold junction, N = Number of couples (or cold junctions).

$$\text{Average m.v. per couple} = \frac{\text{M.V.} + \text{N (m.v.)}}{\text{N}}$$

$$= \frac{\text{M.V.}}{\text{N}} + \text{m.v.}$$

Scales of recording instruments can be calibrated to show average temperatures directly, being specially de-

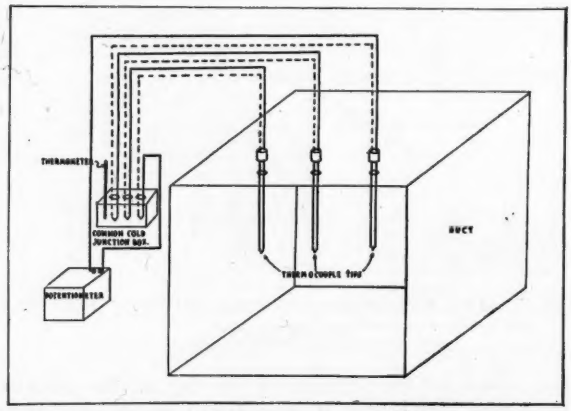


FIG. 2. THERMOCOUPLE CONNECTIONS ARRANGED TO SHOW AVERAGE TEMPERATURE OF AN ODD NUMBER OF THERMOCOUPLE LOCATIONS

signed for the number of couples in the circuit. Automatic cold junction corrections are, likewise, made for more than one cold junction.

Absolute Pressure Gages Used for Test Work

Absolute pressure gages of laboratory construction have been used by the Milwaukee Electric Railway & Light Co. for test work since 1922 with consistently good results. The use of clean Pyrex glass is a prime requisite in making the gages. Clean, dry mercury is equally important and best results can be obtained by putting the impure metal several times through a soft paper funnel rolled into a long small opening at the bottom. One inch columns of the cleaned mercury are boiled through the loops of the gage individually until it is filled to the desired point. Unlike the mercury column and barometer combination, no correction need be made for the reading, which is immediately in the form most desirable, namely, absolute pressure.

Electrical resistance thermometer elements recording significant condenser temperatures in their proper order on a large size temperature scale have been found very satisfactory for studying condenser performance, at the same station. Figure 3 shows a sample of a typical chart with notations. The numbering of the temperatures consecutively from the lowest to the highest assists in reading the chart without a legend and in detecting improper conditions. Temperature differences are shown as distances without referring to the scales and this is an important reason for having all temperatures on one chart.

Summaries of replies covering 210 meter installa-

tions show a wide variety of reported operating troubles, due as a rule to poor design, installation or calibration. In most cases the piping was laid out with reference to securing good metering locations but in some cases the meter installations were made up after the piping was designed, resulting often in unfavorable meter locations.

Inspection of the instruments and piping varied from daily to monthly intervals. The frequency of overhauling the meter and applying water column tests varied from three months to a year. To the question "How long will meters operate without appreciable change in accuracy?" the replies ranged from one month to one year, while one company stated for six years. Many of the replies included weighed water tests of meters. The meters in many cases were very carefully installed and adjusted, and then tested. The results of these tests for 27 recorders ranging from 0 to 100 per cent capacity showed about half the tests to be within about 3 per cent accuracy with a few isolated cases ranging from 15 to 17 per cent error. Tests of 12 integrators over the range from 20 to 200 per cent meter capacity showed a higher average accuracy with the maximum error amounting to about 9½ per cent.

Due to the liability of errors in the installation and sometimes in the design of flow meters, it is advisable to check them by means of a weighed water test in addition to the usual water column test. One company stated: "In view of our experience with wide variations between the readings of various makes of meters connected to a common differential producing device, it is interesting to speculate as to the manner of measuring the boiler feed water for long periods of time in plants reporting unusually high boiler efficiency. In some of these cases it would seem that remarkable boiler performances are sometimes indicated at the expense of the station water rate."

Use of flow meters in central stations is practically universal, but it requires the close co-operation of the manufacturers and the users to satisfy the ever-increasing demand for greater accuracy in flow measurements.

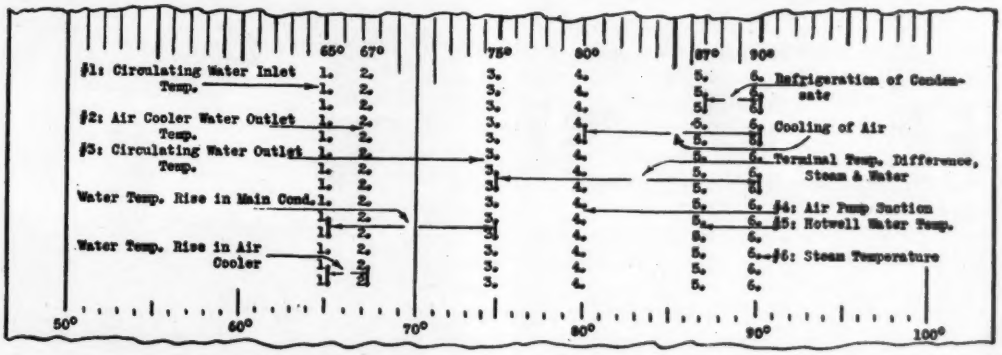

#1: Circulating Water Inlet Temp.
#2: Air Cooler Water Outlet Temp.
#3: Circulating Water Outlet Temp.
Water Temp. Rise in Main Cond.
Water Temp. Rise in Air Cooler
Refrigeration of Condensate
Cooling of Air
Terminal Temp. Difference, Steam & Water
#4: Air Pump Suction
#5: Hotwell Water Temp.
#6: Steam Temperature
65° 67° 75° 80° 87° 90°
50° 60° 70° 80° 90° 100°

FIG. 3. RECORDS OF A MULTIPOINT ELECTRIC TEMPERATURE RECORDER SHOW TEMPERATURE DIFFERENCES AT A GLANCE

Early Steam Boiler Evolution*

FIRST INTERNALLY FIRED BOILER, BUILT ABOUT 1800, WAS OPERATED AT 25 LB. PRESSURE

MOST OF THE papers at the centenary, held June 6 in honor of Samuel Crompton, inventor of the spinning "mule," dealt with textile machinery, but the one by David Brownlie** on Steam Power in Evolution was an account of development from the earliest times with numerous illustrations, a few of which are shown herewith. Early development in England was described by Mr. Brownlie as follows:

To the work of Thomas Savery in 1692 more than to that of any other pioneer is due the efficient use of steam on a large commercial scale. That work was typified by his steam pump, the "Miner's Friend," which was a vessel filled with steam from a boiler, water jets then condensing the steam to create a vacuum which sucked up the water. The vessel was emptied by direct pressure of steam forcing out the water so as to fill the vessel with steam, valves being operated by hand to connect the vessel, first to the boiler, then to the water line. Two vessels, alternately filling and emptying, were used to get continuous action.

About 1705 Thomas Newcomen, a blacksmith and ironmonger of Dartmouth, Devonshire, first used a piston in connection with steam, also originated the beam engine design in his Newcomen engine. Illustration of a large scale model of this engine, recently completed at South Kensington Museum from original drawings of Newcomen is shown in Fig. 1. The original of this engine was erected in 1735 at Fresnes, France, near Paris.

In the evolution of steam power, one of the chief difficulties has been development of a boiler to stand the increasing steam pressures. One reason for Newcomen's success was that he used only 1 to 2 lb. pressure and this could be handled in a "haystack" boiler such as shown in Fig. 2, which was the common type from 1705 to 1785. The illustration is from a South Kensington Model, actual boilers of this type being used in large sizes up to 12 ft. high by 11 ft. diameter and holding 35,000 lb. of water.

During this first great period, with which are associated the names of Jean Francois, Savery, Papin, Marquis of Worcester and Newcomen, the effort was largely for pumping water by blowing steam into a closed vessel, then condensing it to form a partial vacuum, so that

*Abstract of a paper at Crompton Centenary, Bolton, England.
**Assoc. Inst. Mech. Engrs. and member Newcomen Committee on History of Engineering, London, England

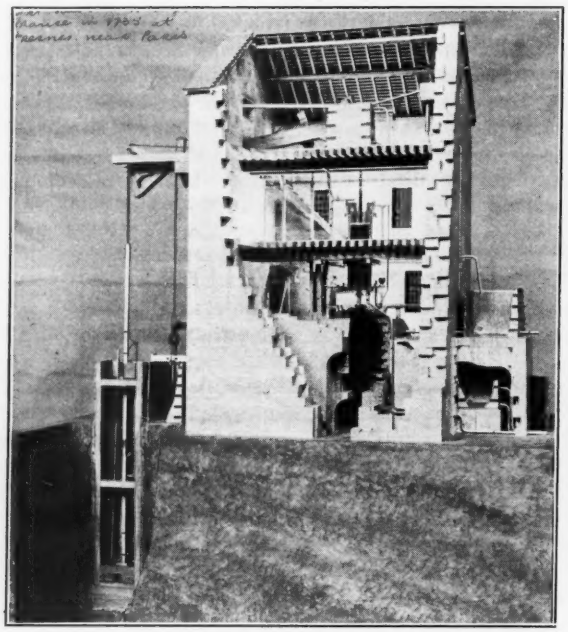


FIG. 1. NEWCOMEN ENGINE OF 1735 USED AT FRESNES, FRANCE

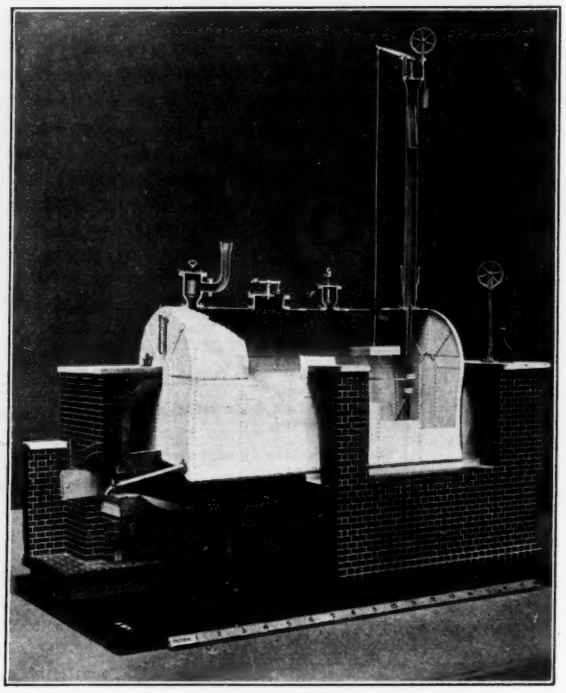


FIG. 3. WATT'S WAGON BOILER WAS AN ELONGATED HAYSTACK USED AT 6 LB.

atmospheric pressure did the work of raising the water.

The next step was represented by James Watt, inventor of the condensing steam engine about 1776, who used pressures of 5 to 6 lb., generating steam in a "wagon" type boiler, which was virtually an elongated haystack as shown by the illustration of the model, Fig. 3. Hundreds of these were installed in Great Britain and Europe up to 1840, although the design was extremely bad both as a pressure vessel and for circulation. Its use is a demonstration of the power of tradition over logic and common sense.

Just before 1800 Richard Trevithick produced an epoch-making invention, the internally-fired cylindrical

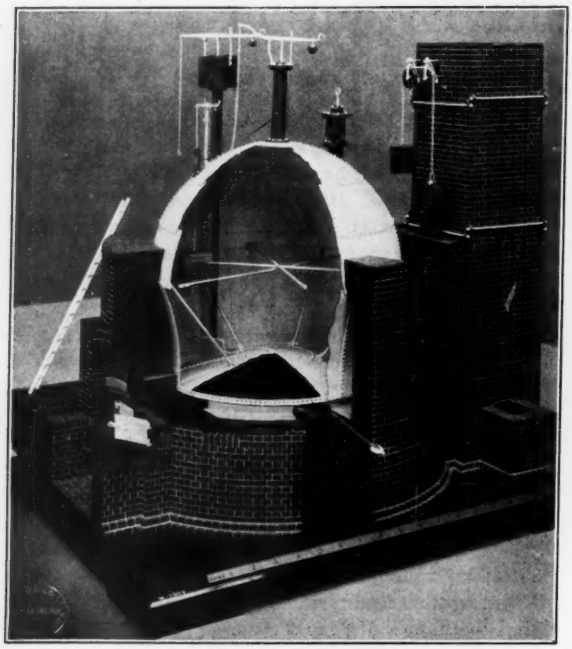


FIG. 2. HAYSTACK BOILER AS USED FOR 2 LB. PRESSURE BY NEWCOMEN, 1705 TO 1785

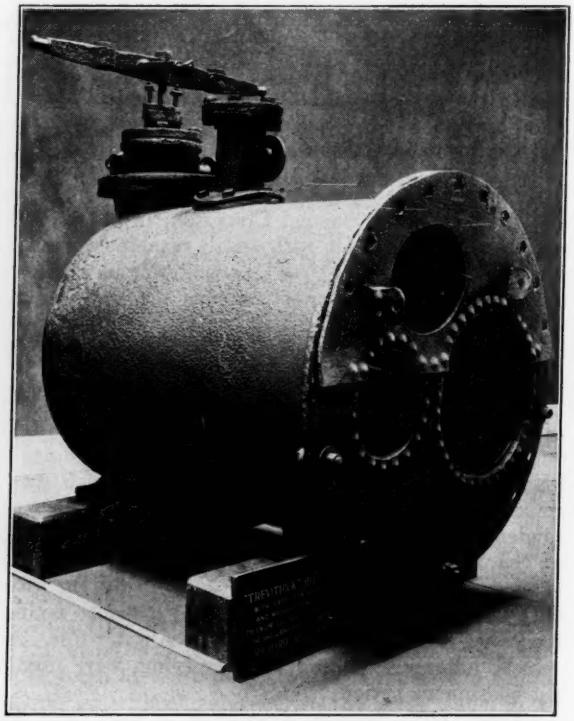


FIG. 4. TREVITHICK'S CORNISH BOILER HAD CAST-IRON SHELL WITH WROUGHT-IRON FURNACES AND HEADS

boiler known as the "Cornish" type from Cornwall, Trevithick's native county. At once pressure was put up to 25 lb. and over, although Boulton and Watt did their utmost to prevent steam pressures above 6 lb. being used. Trevithick, who can undoubtedly be regarded as one of the greatest of power engineers, saw clearly that the future of the steam engine depended on increasing pressures and it is stated that he worked at no less than 160 lb., which was taking his life in his hands with the boiler construction then available. He prophesied that one day 200 lb. pressure would be used, a forecast regarded by Watt as that of a madman. It is interesting to speculate on what Watt and Trevithick would have thought of a proposal for the modern Benson boiler working at 3200 lb. and 706 deg. F., if they had been able to imagine such a thing.

Figure 4 shows a model of one of Trevithick's original first designs with cast-iron shell, wrought-iron furnaces and head bolted on. The engine cylinder is mounted on the boiler and projects inside the shell. What may be termed the first modern pressure power plant was erected in 1800 at the Cook's Kitchen Tin Mine in Cornwall with Cornish boilers for 25 lb. pressure and a beam engine of improved design, using steam "pressure" as the motive force.

One chief result of the Cornish boiler was development of the steam locomotive since the use of pressure of steam as distinguished from vacuum by condensation of steam made a mechanically propelled vehicle practical. To Trevithick is due credit for originating the locomotive, spite of the popular tradition that George Stephenson was the pioneer. As a matter of fact, Trevithick constructed the first railway in the world at Merthyr Tydfil in 1804 and that year sent a locomotive to the Wylam colliery on the northeast coast, from which many others were developed, particularly by Hackworth, Hedley, Blenkinsop and Foster. Stephenson's work and inauguration of the Stockton & Darlington Ry. in 1825 was merely the outcome of these various locomotives which had been running for years. His engine, "Locomotion No. 1," was a mixture of Hedley's and Blenkinsop's designs and contained all Trevithick's pioneer inventions including the Cornish boiler, the gage glass, steam exhausting into the funnel and use of the flanged rail.

Today, said Mr. Brownlie, we are in a state of revolution as regards steam and power greater than in 1827 and present large condensing engines, 3000 to 4000 hp., such as used in textile plants, are doomed as surely as were the type of water wheels used in Crompton's time.

U. S. Water Power Development in 1926*

CAPACITY AND OUTPUT OF HYDRO PLANTS INCREASE, WITH IMPORTANT PROJECTS CONTEMPLATED

WATER POWER PLANTS in the United States reached a total capacity of 11,721,000 hp. in 1926, the year closing with an increase of 544,000 hp. over 1925. There was less completed development in 1926 than in 1925, or 1924 or 1923, but more than in any other preceding year except 1913, when the Keokuk plant on the Mississippi went into operation. Moreover, the increase in capacity in 1926 was above the average, which since 1910, has been at the rate of 460,000 hp. a year.

In the production of energy 1926 was a record year for water power plants. Total output reached 26,188,801,000 kw-hr., or slightly more than 35 per cent of the total energy generated in American central stations. This was an increase of 17 per cent over the 22,355,917,000 kw-hr. produced in 1925, while at the same time the nation's total production of energy increased only 12 per cent. Naturally, the normal stream flow of 1926, following the extreme drouths of the two previous years, contributed materially to that rate of increase in water power production.

More than 70 projects were under construction when the year ended, the various programs calling for the bringing in of approximately 1,100,000 hp. in 1927 and 875,000 hp. in 1928. Outstanding among these projects were the Lock Eighteen development on the Coosa River in Alabama, with 180,000 hp.; the combined power and navigation development at the Falls of the Ohio near Louisville, Ky., with 135,000 hp., and the Conowingo development of 473,000 hp. on the Susquehanna River in Maryland and Pennsylvania and five projects in California aggregating 417,000 hp. Then there was the preliminary permit for the Passamaquoddy tidal plant in the Bay of Fundy, with an estimated ultimate installation of 650,000 hp.

IMPORTANT APPLICATIONS OF THE YEAR

The Federal Power Commission reports that 102 new applications for permits or licenses were filed in 1926. Sixty of those applications were for preliminary permits and 42 for licenses.

Among the noteworthy filings of the year were the four new applications for preliminary permits for projects on the Tennessee River and its tributaries. Eliminating conflicts, these applications contemplate installations of 732,000 hp., but the Commission finds that much of the proposed development is "in conflict with earlier applications upon which action has been suspended pending the completion of the surveys of the Tennessee River and its tributaries, now in progress under the War Department."

An application for a preliminary permit on the Cumberland River in Kentucky proposes an installation aggregating 133,000 hp., while another contemplates the development of 40,000 hp. at another point on the same stream.

Development of the Colorado and St. Lawrence Rivers is still held up. This is what the Commission says as to the Colorado: "All cases affecting the Colorado River are carried in a suspended status in accordance with a policy which the Commission deemed it best to adopt pending attempts by the Colorado River states to agree upon a plan for the distribution of the waters of the river."

As to the St. Lawrence, the Commission reports: "Action upon extensive developments proposed on the St. Lawrence River likewise continues in suspense awaiting the report of consulting engineers to the International Joint Commission and the adoption of a general

*Abstract of report of Water Power Development Committee of the N. E. L. A. for 1926-27, presented at Atlantic City, June 6-10.

scheme of development acceptable to the United States, to Canada, and to the State of New York."

Activities of Federal Power Commission

Extent of the work done by the Federal Power Commission is shown by the fact that it has handled 726 applications for permits and licenses since it was organized in 1920. Licenses have been granted on 215 of these applications and 220 have been rejected or caused to be cancelled or withdrawn. The balance are in various stages of study and investigation.

The number of applications rejected indicates that the Commission has acted with discretion and caution. Apparently it has rejected the unworthy yet has not stood in the way of legitimate undertakings. Speculation in permits, which once threatened to become an evil, seems to have been curbed and controlled.

An outstanding event of 1926 was the exercise by the Federal Power Commission for the first time of its power to regulate the issuance of securities by corporations engaged in the development of licensed projects. Exercise of this power was made in connection with the Conowingo project on the Susquehanna River in Pennsylvania and Maryland.

The number of applications for permits and licenses should not be regarded as assuring a continuation of the present rate of activity in the development of water power. Many of the applications filed during the year were for projects selected and planned before the economic trends of today became so clearly manifest. Water powers nearest the available markets have now largely been developed and put into service. So too have the more distant water powers requiring the lowest investment. Utilization of resources not yet developed must necessarily be expected in some cases to entail higher investment costs, longer and more expensive transmission lines, and higher prices for lands and rights of way. A good proportion of the best hydro developments have already been made.

Contrasted with this, there is a downward trend in the cost of energy produced by steam. Notable improvements in plant design have been effected during recent years that have resulted in marked improvement in efficiency and a substantial reduction in the cost of producing energy. While water power will never cease to be a great national asset, the achievements in steam production have created a noticeable tendency to postpone the development of power by water. Indeed there are already instances where water powers, selected for development 2 or 3 yr. ago, have been deferred for the present and steam plants installed instead. There are other instances where steam in recent months has been brought in to supplement water power to a degree that a few years ago would have been regarded as unnecessary.

On most of the great streams of the country, the development of water power is completely held up pending the enactment of necessary legislation that, in turn, has become involved in the meshes of politics. But industry declines to wait, and engineers, fighting to bring down costs, have improved the development of power by steam to the point where more than one large water power project has lost its place in the sun and projects that were considered attractive 5 yr. ago no longer appeal to capital. Economic and natural laws are inexorable and neither the romance of "white coal" nor popular interest in natural resources can make capital develop a water power where an equivalent amount of energy can be produced from steam for less money.

Commercial Efficiency Should Be Considered

IMPORTANCE of commercial efficiency was stressed by Joseph Harrington in a paper read before the American Wholesale Coal Assn. at Toronto, Ontario, on June 6. This paper, dealing with recent developments in the preparation and use of powdered coal, states that the year has seen a much more balanced attitude in regard not only to the question of powdered coal and the use of stokers, but between the various advocates of the different powdered coal systems.

Any analysis which does not take into account the ultimate cost as well as the efficiency of the various units and combustion efficiency is neither complete nor correct.

DIFFERENT COALS REQUIRE DIFFERENT DEGREES OF PULVERIZATION TO GIVE PROPER COMBUSTION

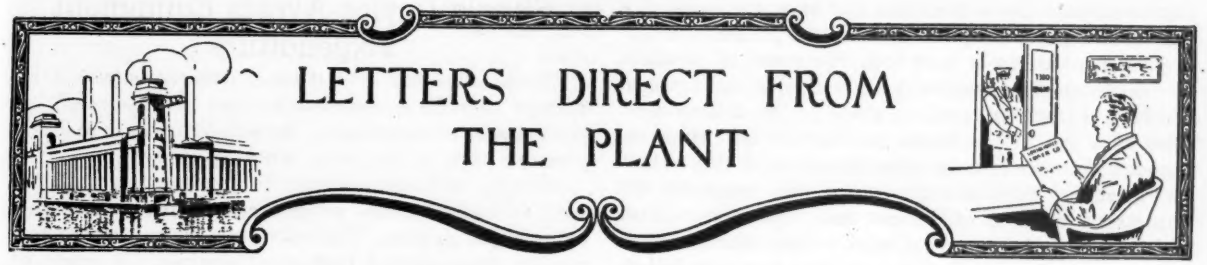
Coal	Fairmont, W.Va.	Shamokin District Anthracite Culm	Fairmont, W.Va. Culm
Fixed Carbon	59.6 per cent	69.84 per cent	52.69 per cent
Volatile	33.53	6.39	23.08
Ash	6.87	23.76	25.7
Fineness: through			
50 Mesh	95 to 98	100	
100 Mesh	80 to 85	98.5	
200 Mesh	67 to 70	87	86 to 87
Kw.hr. per T.		10 to 12	7

It is a rule of life that we must pay a higher price for the better thing so, in the terms of a combustion engineer, "We must pay for efficiency."

Effect of high moisture and ash content of coal to be pulverized in increasing the power consumption and maintenance of pulverization equipment were sketched briefly. Water walls should be laid out only after due consideration of coal to be burned, as it is possible to have so much cooling surface with low volatile coals that the temperature of the furnace is reduced to a point where the flame will go out.

The importance of degree of fineness of pulverization was pointed out and figures in the accompanying table show three coal analyses, specifications and pulverizer power consumption, as given by the Bethlehem Steel Co. for coal for boiler and metallurgical furnace use. The development of turbulent burners, air preheaters, and experimental use of pulverized coal locomotives was touched upon and, because of the tendency toward the use of unit pulverizers, a rather detailed comparison of the equipment required in the bin and unit system of pulverized coal firing was given in order to point out the fundamental differences in the two systems.

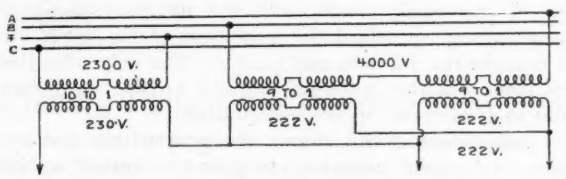
DO NOT CONDEMN a lubricant for machinery failure until you are sure the right oil is being used for a required service. If a locomotive is too heavy for any given road bed, it does not necessarily follow that the locomotive is a bad one.



Three to Two Phase Transformations Using Standard Transformers

NEVER HAVING SEEN ANYTHING printed in periodicals on the subject, the author desires to "pass along" the method in general use by an eastern electric company for transforming from three phase to two phase. Below is a wiring diagram showing how the three standard transformers are connected. It will be seen the primary must necessarily be a four wire Y circuit.

Since most so-called "standard" transformers have 9 to 1 and 10 to 1 taps, the above method of connection



CONNECTIONS FOR TRANSFORMING THREE PHASE TO TWO PHASE WITH STANDARD TRANSFORMERS

has proven most economical in that it does not necessitate special 87 per cent tap transformers as required by the usual Scott connection. In the past experience of this company the slight unbalance in the voltages has not been objectionable.

The 10 to 1 transformer is usually about 1½ times the capacity of the 9 to 1 transformers; for instance, one combination often used is a 7½ kv.a. (10 to 1 ratio) with two 5 kv.a. (9 to 1 ratio) transformers. This, of course, is because the two (9 to 1) transformers carry approximately one-half the load while the (10 to 1) transformer carries the other half of the load.

Since the two (9 to 1) transformers are operating at below normal voltage, the kv.a. capacity is therefore reduced. In the case cited above, the two (9 to 1) transformers are able to carry safely about 8 kv.a. at the voltage on which they are operating and so with the 7½-kv.a. transformer make up a fairly well-balanced bank.

VERNON W. PALEN.

Comment on European Supremacy

YOUR EDITORIAL on European Supremacy on page 649 of your issue of June 1 is certainly a challenge and it would be a sad thing if it were not answered by some lone reader on this side of the Atlantic. John Paul Jones might have sunk the entire British fleet; I am hardly qualified to discuss the point because this is the first time I have heard of the possibility—history is not much in my line. And what Washington could have done to the British, though it makes me shiver to think of it, had better be left to more qualified speculators than the writer. The English and Scotch, after hundreds of years, are still refighting the battle of Bannockburn, and let us hope that healthy national pride keeps them at it.

As a Britisher who has been connected with power plants since graduating, and who has worked in some of the crack American plants of the day, I have at any rate been able to form my own opinion. After doing my first two jobs in the Middle West I returned to New York where my chief asked me how I thought British and American plants compared. This was in the day when Milwaukee led the world, and that plant gave me the biggest eye-opener I had, next to the Grand Canyon. I said that I thought American turbine rooms were five years behind British practice and that the boiler houses were five years ahead. I was wrong, America has done in two years what I thought would take five.

Recently Mr. Alex. Dow visited this country and gave his opinion that so far as turbine rooms compared there was nothing in it, but when asked about our boiler houses he was reticent and it is pretty obvious that he thought we might do better there. There is not the slightest doubt that we can. Here the boiler business is almost a monopoly and all the virtues and benefits of keen competition, which exist in America, are lost. The same old thing has only one virtue and that is its cost; it is absolutely unsuited for really high pressures and rates of steaming. Many better and more scientific designs have been bought out of the market and it is impossible to estimate what it has cost this country. British engineers are realizing that they have been let down, and are asking for what they want, and not taking what they get.

There are other reasons for our seemingly poor plant performances. We are a poorer nation than we have been for years and we of this generation realize that it is not a lot of fun to win a war. We simply can not afford to take risks, while America is in a better position than ever to make experiments. Ten years ago we led the world in stepping up to high pressures, developing reheating and generative cycles, then we had to stop and let other people make a job of it; we are very good at this. Mr. Alden's remarks regarding the B.t.u. per kw-hr. got from our plants are quite correct. With the very high load factors which many of your base-load stations enjoy, it probably pays to aim high; here one of our leading stations has, in its new extensions, deliberately sacrificed thermal efficiency, but it will cost the consumer less for his power. This is a point which will surely go home with an American.

The Britisher will have to get out of the habit of doing things by committees. We have all sorts of commis-

sions and executive committees and after the lapse of a year or so reports are published and the job gets started. A prominent engineer here took two years to persuade his enlightened committee to adopt equipment which had been thoroughly tried out abroad. But I have memories of a job in California in which 9 mo. after the foundations were laid on piles in soft sand two 40,000-kw. machines were turned over. I also remember the unpleasant number of boilers and superheater tubes which failed owing to rushed work—apart from a serious furnace explosion in which a number of men were killed; it cuts both ways. As an Englishman and great admirer of America, I can only say that we have a lot to learn from one another and the more we do it the better it will be for us both.

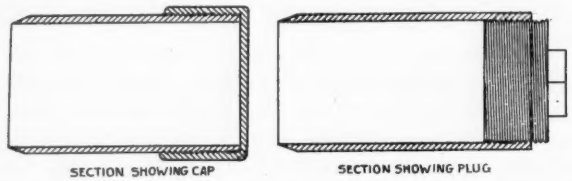
Northwich, England. B. M. THORNTON.

Durable Gasket Cutters

CUTTING THE smaller gaskets by hand is a tedious job, a dangerous one and not only is time lost in cutting them but the finished product is not one of first prize class.

It is possible, with a little patience, to construct a set of cutting tools that will give indefinite service and prove highly satisfactory.

The parts required are pieces of iron pipe about 4 in. long and either plug or caps to fit these pieces of pipe.



IN USING THESE GASKET CUTTERS, USE A LEAD BLOCK AS A BASE IN CUTTING GASKETS. THEY CAN BE USED UP TO 3 IN. AND BEING CONCENTRIC, THERE IS NO WASTE IN ANY SIZE

The pipe size determines the inner and outer diameter of the gaskets to be cut.

The first operation in making these cutters is to thread the pipe to take a cap or plug and the next is to taper the cutting edge to a knife-like sharpness. This can be done first with the emery wheel, and then with half round files until the proper cutting edge is produced.

Then the plug or cap is screwed on and the cutter case-hardened by a competent man, as it is this operation that determines the life of the cutter.

Case-hardening can be accomplished by heating the cutter to a cherry red, with due respect for the knife edges, and pouring potassium cyanide on the heated part after which it is returned to the fire for further heating to the cherry red of the original heating. Then it is once more removed from the fire and a thorough application of potassium cyanide is again applied, after which it is immediately quenched in water.

A set of these cutters can be made in a very short time and will be a valuable adjunct to any department using miscellaneous small gaskets, due to their saving in time and material as well as the better resulting product.

Aurora, Ill. E. J. MORRISSEY.

Simple Device Avoids Equipment Expenditure

SOME ENGINEERS will try out different ideas in an attempt to reduce some trouble and often succeed beyond their expectations. Here is a case. A back-pressure valve rattled very much on its seat.

Several different schemes to prevent this rattling, such as using balance weights and springs, were tried out without success. This valve was on an exhaust line coming from several high-speed engines. A piece of 2-in. galvanized iron pipe, capped on one end, was set solidly under the valve lever. A plunger was made by placing a leather cup washer between two metal washers, the leather being fitted loosely in the 2-in. pipe. A ¼-in. piece of pipe, open at the ends, served as a rod between the plunger and the valve lever, two locknuts being used to hold the plunger together and a fork being used to attach rod to lever.

We thus had a dashpot that acted as a snubber. The action was as follows: On the downward stroke the water with which the 2-in. pipe is filled is forced up into the ¼-in. pipe. On the upstroke the water flows between the leather and the side of the 2-in. pipe. The use of this easily made outfit did not vary the back pressure any or retard the movement of the lever, but it brought the valve to rest quietly. The only attention required was that necessary to add a little water now and then to make up for evaporation.

Installation of this simple device saved the cost and time that would have been required to install an improved back-pressure valve whose purchase had practically been decided upon before the dashpot idea had been tried.

Toronto, Canada. JOHN THORN.

Flexible Joint Allows Misalinement

WHEN CONNECTING up a motor to a machine or line shafting, it is very essential, if alinement is not perfect, that some form of flexible coupling be used between the motor and machine or shafting. Otherwise, a strain

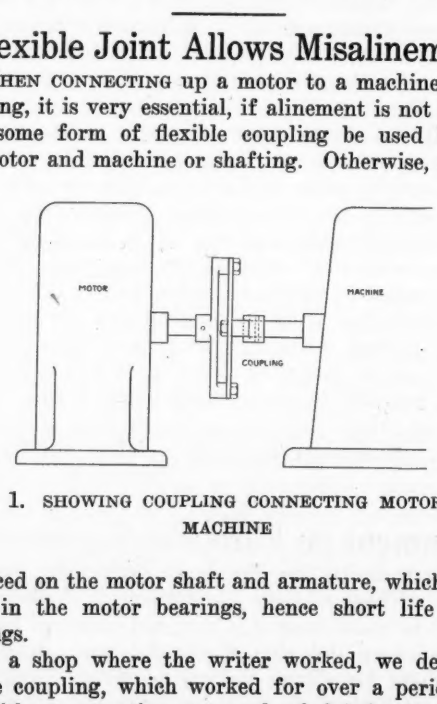


FIG. 1. SHOWING COUPLING CONNECTING MOTOR AND MACHINE

is placed on the motor shaft and armature, which causes wear in the motor bearings, hence short life of the bearings.

In a shop where the writer worked, we devised a simple coupling, which worked for over a period of 5 yr. without attention or need of lubrication. This coupling is shown connecting a motor to a machine in Fig. 1, in which two identical jaws are used. Figure 2

shows the details assembled at A. The sheet metal deflection disk is shown at B and the forged steel arm at C. These jaws are attached permanently to a center ring disk made of sheet steel.

This coupling can be made up in any size. It will take care of both angular and lateral distortion. In

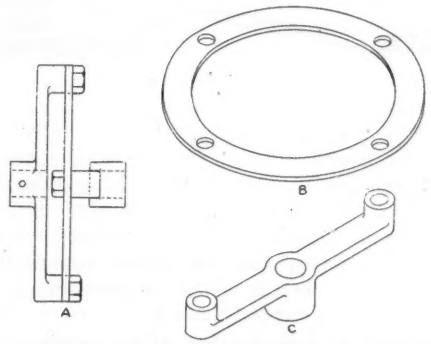


FIG. 2. SHOWING DETAILS OF FLEXIBLE COUPLING AND PARTS ASSEMBLED

extreme cases of misalinement, it is advisable to introduce a short section of shaft and use two of these couplings.

Washington, D. C. G. A. LUERS.

Placing Pulleys for Quarter Turn Belts

A YOUNG MILLER who owned his own mill and who had aspirations to be a millwright as well as a miller, got into serious trouble while trying to arrange pulleys upon two shafts at right angles to each other in such a manner that a belt would drive one shaft from the other and not "run off."

In despair the young miller called in an old millwright friend, related his "tale of woe" and turned his friend loose with the crosswise shafts and their pulleys. The old millwright moved the pulley sidewise a few inches on the old shaft, squinted along one edge of that pulley, then climbed up a ladder to the overhead shaft and squinted and moved that pulley also. He then returned to the lower pulley, performed the same operation again but this time he moved the pulley only about one inch. Again returning to the upper pulley, an adjustment sidewise of about ½ in. was made, then both pulleys were securely tightened upon their respective shafts.

Passing a tape measure around the pulleys, the belt length was determined, the belt cut off, laced and put in place. Power was then turned on and that ¼ turn belt ran as true upon its pulleys as any other belt in the mill. "How did you do it?" the young man asked of his friend.

"It was done in this way: I sighted past the delivery side of the lower pulley. That is, the side from which the belt left that pulley. I moved the lower pulley into such position that the belt coming from it would track fair upon the receiving side of the overhead pulley. Then, at the upper pulley, I did exactly the same thing, shifting that pulley slightly so that the belt leaving it would be received squarely upon the receiving side of the lower pulley."

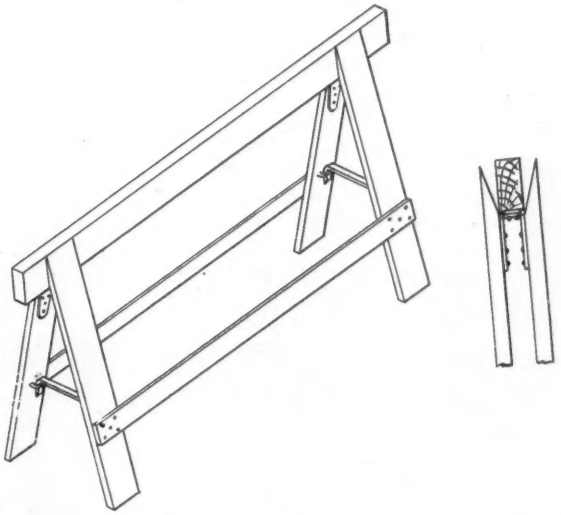
"Yes, but how about the manner in which the belt leaves either pulley?"

"I paid no attention to that matter except to estimate approximately where the belt would twist off a pulley. It comes off a little early, you know, and from that point the belt must run squarely towards the receiving side of the other pulley. No further attention need be given to the manner in which the belt leaves either pulley. It is essential only that the belt approach the driver pulley, in each case, in a line perpendicular to the shaft on which the pulley is placed and in the center of the face of that pulley. It is not necessary to use a line in setting the pulleys.

Indianapolis, Ind. JAMES F. HOBART.

Folding Construction Makes Horse More Convenient

LARGE wooden horses as used in many plants are awkward to handle and take up a lot of unnecessary floor space when not in use. The type of construction



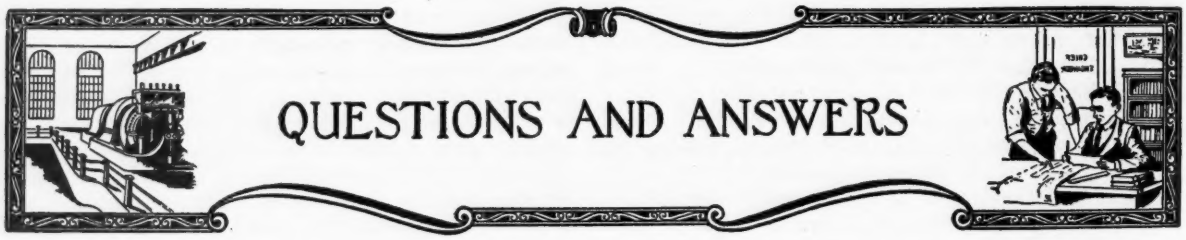
FOLDING LEGS OF HORSE REDUCES STORAGE SPACE REQUIRED AND INCREASES EASE OF HANDLING

shown in the illustration eliminates all of the objectionable features of the conventional styles. This horse is much more easily handled and requires less than one-quarter the floor space for storage.

The legs are attached to the top cross member with heavy butt hinges which allow them to fold close together when not in use.

Syracuse, N. Y. H. L. WHEELER.

BELIEF is somewhat current that there existed among the ancients an art of hardening copper which has been lost. In fact, metallurgists now can harden copper and bronze to give products harder than those left by ancient peoples. Two methods are used, alloying with other metals such as zinc, tin, nickel, aluminum and others, or cold working by hammering, which is the ancient method for developing cutting edges on swords and knives. Cutting tools are, however, better made of steel unless some special reason exists for using copper.

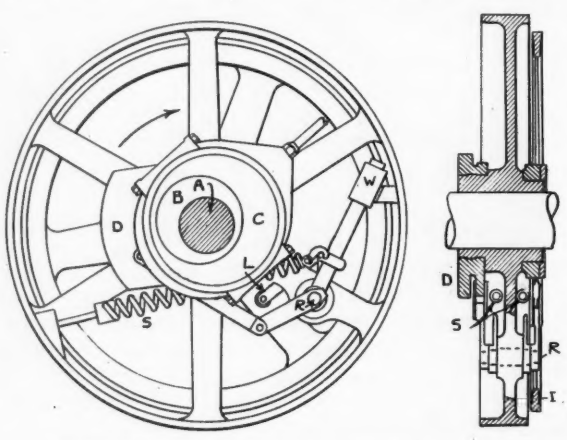


Valve Motion and Governor Problems

PLEASE LET me have answers to the following questions:

1. How is the proper length of eccentric rod found?
2. What four reasons are there for having compression in a steam engine?
3. How does a double eccentric type shaft governor operate?
4. Why cannot slotted eccentric type shaft governors be used on riding cutoff engines? N. A. B.

A. Unlike the connecting rod, the eccentric rod is so long in proportion to its movement that the slight distortion to this movement due to the angularity of the rod is usually not considered. The length, therefore, is governed by the length of the engine; its only need is to connect properly the eccentric and slider connection of the valve rod or rocker arm, if a rocker arm is employed.



SHOWING DOUBLE ECCENTRIC SHAFT GOVERNOR

2. Compression is employed first, because this fills the clearance space with steam at or approaching entering pressure; second, to take up the inertia of the moving parts, bringing them to rest quietly and causing the pressure on the crankpin and crosshead pin, at the end of the stroke, to be on the same side of the pin as that occurring at the moment steam is admitted into the cylinder, thus avoiding knocking which would otherwise take place; third, a minor beneficial effect is a slight prevention of initial condensation when the steam enters the cylinder due to the fact that the pressure has been raised by compression at the end of the stroke, and the heat of compression, as well as prevention of further drop in pressure, raise the temperature of the steam slightly at the end of the stroke; fourth, a slight effect toward balancing the valve by raising the pressure on the under side of an unbalanced slide valve. This tends to make the movement of the valve slightly easier than it would otherwise be at the end of the stroke of the piston.

3. The double eccentric type of shaft governor consists of two eccentrics, one inside of the other as shown in the illustration. The inner eccentric B is turned on the hub of the wheel A, while the outer eccentric C and its counterweight D are carried around the inner eccentric by the motion of the governor, changing both the throw of the eccentric and the angle of advance.

The operating mechanism of the governor consists of a weight W, pulling against the spring S and revolving rocker shaft R, which moves the eccentric C through link connection. To the other end of the shaft R is fastened an inertia wheel I, which revolves within the governor pulley and acts upon the rocker shaft R through the link L. The proportion of the inertia and centrifugal effect can, therefore, be changed by the position of the weight W and its amount.

4. A slotted eccentric type of shaft governor cannot be used on a riding cutoff valve because the throw of the valve must remain constant for any cutoff. Moving an eccentric across the shaft, in any way, changes the throw of the eccentric.

Relation Between Coal Consumption and Developed Horsepower

HOW MAY I determine the number of pounds of coal required to furnish enough steam to serve one engine rated at 625 hp. and another rated at 210 hp., both engines taking steam from a common source and at the same pressure and condition. The larger engine runs 97 hr. a week; the smaller engine, 111 hr. a week.

What would be the coal consumption if the average load on the larger engine was 600 hp. and on the smaller engine, 245 hp.? S. H. W.

A. So much pertinent data is lacking in your question that no reliable estimate of possible coal consumption could be made. Three major items must be known; first, the heating value of the coal used; second, the water rates of the engines running under the given conditions; and third, the evaporative capacities of the boilers, operating under the given conditions.

Water rate of an engine depends principally upon the kind of engine, whether simple, compound, etc.; on the kind of valve gear and governing; on the size, speed and load of the engine; on the temperature and condition of entering and exhaust steam; and on the efficiency of operation. Water rates vary from 5.5 lb. per i.hp. in the most economical grades of condensing engines using highly superheated steam to 60 or 70 lb. in small non-condensing engines.

Evaporative capacity of a boiler depends principally upon the draft, kind of coal and efficiency of heat transference. Evaporative rates vary from about 11 lb. water

per pound coal in fine high pressure water tube boilers to less than 3 lb. in poorly operated very ordinary boilers.

If we knew the three major items indicated, we could easily calculate the pounds of coal required from

$$C = W \div E$$

where C = pounds of coal required
W = water rate of engine in pounds water per i.hp.-hr.
E = evaporative rate of boiler in pounds water per i.hp.-hr.

If, for example E = 7 and W = 21,

$$C = 21 \div 7 = 3 \text{ lb. coal per i.hp.-hr.}$$

Tests of the engines and boilers under the various conditions of service, such as load, etc., would alone give you adequate values. But tests alone are not sufficient as a guide to efficient operation; proper instruments should be installed to permit the engineer to see the effect of operating in different ways and to enable him to find the best way for a given condition. Recording instruments help the engineer in analyzing his conditions of operation and also permit the management to see how efficiently their power staff is performing. Adequate records and proper instruments take the guess work out of operation.

Problems in Steam Engineering

PLEASE ANSWER the following questions:

1. Where would you measure the plate of an h. r. t. and B. & W. boiler in order to determine the thickness?

2. How would you reset a B. & W. boiler if it has sagged?

3. What causes the nipples in a mud drum of a water tube boiler to leak and what would you do to prevent them from leaking?

4. Can you renew the seat and disc of a pop safety valve, or do you have to grind them in?

5. What is the advantage of the double ported valve in a Corliss engine?

6. What causes a water glass to wear thin at the top?

7. How can you test for leaky tubes in a surface condenser, without filling it up with water, or measuring the condensate?

8. Why is the shearing strength of rivets in single shear greater in proportion than that of rivets in double shear?

9. What is the advantage of a beveled seat over a flat seat in a pop safety valve?

10. What is the main difference between a steam turbine and a reciprocating steam engine?

11. Why can't a duplex pump be used as a dry air pump? M. M. D.

A. At the girth seams, above the water line.

2. If the boiler is supported on steel pillars, the first thing to do is to shore up the pillar or pillars that have sunk, then construct a wooden form around the base or bases and pour concrete or cement, depending upon the amount of sag, into this form. If the support is of brick, the shoring up may be done by opening up the brick setting at the base in a number of places and placing screw jacks in these openings with the plates above the jacks to distribute the load. After the sag has been removed, one after another of the openings may be rebricked.

In either case, all water should be removed from the boiler before starting operations, and the brickwork should be pointed up after the job is otherwise complete.

3a. Improper expanding, which may be remedied by proper expanding.

b. Unequal stresses due to mud drum carrying part of the weight of the boiler, in which case it is only necessary to relieve the mud drum of this load.

4. Many pop safety valves have removable valve discs as well as seats. They may, however, be ground in, in a manner similar to that used on automobile valves.

5. A double ported valve of any description has the advantage over a single ported valve of the same type, of opening and closing twice as fast.

6. Steam erosion, due principally to impurities in the steam.

7. Empty the condenser, put the tubes under a vacuum, and then pass a lighted candle along the tubes. The flame will be drawn in wherever there is a leak.

8. Because of the short distance between the two applications of distortion on the same rivet, in the case of double shear, the distortion at the one point affects the resistance to distortion at the other point.

9. The advantages are: larger opening for a given amount of lift, greater amount of seat surface for a given diameter and better seating effect due to centralization.

10. One characteristic difference between a steam turbine and a reciprocating steam engine is that in the former, the steam expands in alternating sets of stationary and moving blades or nozzles and blades, the latter being attached to a rotating shaft while in the latter the steam expands against a reciprocating piston which actuates the shaft usually through a piston rod, crosshead and connecting rod.

11. Because the valves are too heavy and too much clearance exists in a duplex pump.

Boiler Operation and Setting

1. HOW WOULD YOU proceed to blow down a steam boiler which is under 300 to 400 lb. pressure?

2. What determines the distance between the back end of a return tubular boiler and the back wall? B. I.

A. No boiler should be entirely blown down or emptied when a hot fire is under it. If the blowing down is, however, only for the purpose of removing sludge or sediment, the blowoff valve should be opened for only a short time at frequent intervals. A good method to follow is to open the valve gradually until it is wide open and then, at once, slowly close it again. If there is a valve and a straightaway cock, the cock should be opened first and then the valve. Close in reverse order.

2. The distance from the shell to the back wall in usual practice is as given below.

Dia. shell, inches	30	50	70
Distance, inches	16	18	24

The distance is governed by the cross-sectional area of the passage at this point. This area must be greater than the cross section of the flue in direct proportion to the reduced volume in the flue due to reduction of temperature of the flue gases.

EDITORIAL COMMENT

Passing the Buck in Engineering

Passing the buck, although often referred to as the old army game, has been so widely adopted by civilians that it no longer recognizes its master. Perhaps like so many other things we can safely blame this on the war, a polite variation of the original game popular with those too lazy to look for the real cause. Like many others we too sometimes find the war a convenient peg to hang things on.

Now engineers, having that wonderful analytical mind we read about in some of the semi-popular and Sunday supplement pages, take the buck and with the skill of a learned surgeon dissect him into small pieces which can be surreptitiously slipped into the pockets of poor unfortunates. Of course occasionally this same engineer will spot a little henpecked helpless fellow and find it more convenient to pick the buck up by the horns and throw it bodily at the little fellow who, as is often the case, will be smart enough to take the buck around the corner and sell it for venison.

Educators are fairly good at passing the buck too and when the two get together it is well for everyone else to keep a careful watch. Recently at such a meeting the discussion at first centered around the most useful training, or rather college course; that is, what course would be the best to pursue, if the student were likely to drift into any one of a score of occupations after completing it. Opinions differed, but the choice was either law or engineering. Law has some strong arguments, especially the data from the army files of the war showing the high ranking of law-trained artillery officers. Law, however, being in the minority was voted down in the favor of engineering.

Next the happy-go-lucky attitude of the average student was brought up to point out how much chance had to do with his decision or indecision to take a certain course. Natural aptitude and logical deductions appeared to have little bearing on the selection while until at or near the time of graduation the majority give little thought to their future connections.

Naturally such discussion led to the matter of limited enrollments and elimination, both necessary, perhaps, in the case of a school with fixed finances and able to take care adequately of but a limited number. This, however, does not solve the educational problem; rather it adds complications. With the increasing prosperity of the country and increase in educational standards bringing the general educational level close to that of the college graduate, an increasing number of students are going to college. They are not thinking of going,—they are going,—if not to one place to another.

The real problem is to take care of this increasing number in the best way. If it is admitted that students go to college without a definite idea and that an engineering course is the best one to pursue for general purposes, why is it not logical to build up the engineering schools rather than to try to limit their enrollment?

There is no need to argue over whether or not in this democratic country everyone is entitled to an education or whether in the interest of economy and professional pride careful psychological tests should determine a picked few to be given an engineering education. The point is that they are going to college regardless of arguments for and against and they should be taken care of to the best advantage. Eliminated from the engineering college, they will turn to other schools, the net result being that the buck has been successfully passed by the engineer and by the engineering educator.

Why not accept the fact that engineering schools are not now getting, never have and never will get what they consider well prepared students so they can plan accordingly? Do the testing and selection during the undergraduate years, when the student is under the observation, care and grading of a single organization, give students especially adapted to advance in engineering thorough graduate training. Medicine and the better law schools use the undergraduate's work as a basis for the real professional training, and if engineering is to be ranked in the same class professionally, surely we can afford the two or three extra years. In any case there is little to be gained in passing the buck to others either in small pieces or as a whole, to be passed on by educators, to subeducators or coeducators in the other colleges.

Impending Changes in Our Use of Fuels

It is significant that when Arthur D. Little discussed "Impending Changes in Our Use of Fuels" at the annual meeting of the Engineering Foundation last May, the emphasis of his speech was laid upon better use of coal and increasing use of manufactured and natural gas for all types of domestic, industrial and power plant work.

Better use of coal is being sought at present through the various processes for low-temperature carbonization of coal that are in use both in this country and abroad. While all the processes used in this country have not yet established definitely a commercial status, certain of them will probably do so in the near future. The immediate opportunity for these processes lies in the conversion of the immense available amount of cheap slack and screenings to a high grade domestic fuel. For a long time to come raw coal, of course, will continue to be the economical fuel for large power stations, except in cases where low-temperature plants, gas works and steam central stations can be tied together.

Not long ago a prominent utility executive referred to the latter possibility. Dr. Little alludes to the formation of a German company which plans to conduct "all processes which use water, air and coal," beginning

with those which can be applied immediately and developing those which need further investigation.

Concerning the use of gas for industrial and domestic use, the expansion period on which the gas industry is now entering will demand a great deal of research work. Long distance gas transmission lines for both natural and manufactured gas, such as those projected in this country and in connection with the German company referred to above, may bring about great changes in the industry, in conjunction with the carbonization processes. Limitation of water supply near mines would not preclude location of gas works there, as it does the location of power plants.

Commenting on the use of gas in industry and also in the home, Dr. Little stated that the domestic gas refrigerator offers possibilities of economy; in the light of this, it is interesting to note that one of the large and established makers of electric refrigerators has announced such a domestic gas refrigerator.

Dr. Little is in a position to know whereof he speaks on the above subjects and we feel that he has performed a service to the profession by analyzing the present situation so clearly. New developments occur with startling frequency, pointing toward possibilities of economy by a combination of utilities supplying electric power, district heating, domestic and industrial gas, various types of fuel and chemicals, all functioning as a single, co-ordinated organization. Such an organization could be justified only by the elimination of much of the waste involved in our present methods of burning fuels. Nevertheless, the engineering profession has aroused some interest among industrialists in eliminating this waste by the foregoing method. As this interest increases and further research work is performed, we may look forward with considerable confidence to greater economy in our use of fuel.

To the Solid Ground of Nature

In one of his characteristically instructive articles Dr. Paul Heyl of the Bureau of Standards in the current issue of the Scientific Monthly discusses man's close relation to nature and as a basis for his theme quotes Wordsworth's lines:

"To the solid ground
Of nature trusts the mind that builds for aye."

Much as we feel inclined to do so, it is not our purpose to review Dr. Heyl's article here, but it has a bearing on certain matters of interest to engineers and it is from this angle that we refer to it.

There has been considerable discussion recently as to the proper method of training engineers in colleges and the proponents of specialization on the one hand and of broad training on the other have voiced their opinions at length. Without attempting to underrate the value of specialization in engineering, it seems to us that an engineer, by virtue of his constant dealing with the forces and materials of nature, should have a sound footing on "the solid ground of nature." Just as all phenomena exhibited by inanimate matter is based upon the fundamental mechanics of the atom so must an engineer's knowledge of complex engineering problems be based upon the fundamental laws which govern the mechanism of atoms. With a definite knowledge of these laws he can solve problems exhibiting the most complex phenomena.

This is nature's own method. Resolved to its ultimate, there exists in nature probably little more than the single force between the electron and the proton. Yet, with this simple foundation, nature has no difficulty in solving the most complex problems instantly. This quality, says Dr. Heyl probably appeals most strongly to the mathematician or astronomer. By means of the most powerful methods known we can scarcely attain an approximate solution of the problem of three bodies, yet this and far more complicated problems are daily and hourly handled by nature without the slightest hesitation in the motions of the heavenly bodies and in the atom. The terms "simple" and "complicated" are meaningless to nature for she recognizes only the simple forces—complicated actions follow as an inevitable result of simple elemental forces.

Engineering has become enormously complex during the past quarter of a century, so complex, in fact, that only a man who devotes all his time and energy to a particular branch or sub-branch of engineering can hope to know all there is about that branch. The discussion of one group, of electrical engineers, for instance, at a meeting of the A. I. E. E. may be almost unintelligible to another group of electrical engineers but specializing in a different branch of the art as it is to a group of mechanical or civil engineers. The man who specializes on power transformers may be entirely at sea at a meeting of the communication section, and vice versa.

If one attends such a meeting, however, it will be found that there is always a small group of men who can be found at almost any of the section meetings and who seem to be able to discuss almost any question that is raised, regardless of whether it has to do with the design of a loud speaker horn, the performance of a synchronous converter or the characteristics of a circuit breaker. These men often contribute the most interesting discussion and raise questions which even those qualified to call themselves specialists in the field have difficulty in answering.

These men, men like Karapetoff, Mailloux, Kennelly, are the men who have a solid grasp of the fundamentals of electrical engineering—who, to re-use the term, stand on the solid ground of nature. They may be specialists; they make the best specialists in fact, but their knowledge is based on a clear understanding of fundamentals, and it is this knowledge of fundamentals that gives them their understanding of the whole.

Specialization based on fundamental knowledge is a thing to be desired, to be encouraged. It will bring about continual improvement and will guide the art, whatever it may be, along the broadest, the most permanent and most suitable lines. Specialization without fundamental knowledge is a dangerous thing, a practice which, if persisted in, will only lead along restricted paths away from all further progress and development.

EXPORTS of electrical equipment from the United States during 1926 were valued at approximately $97,000,000, which represents an increase of about $8,000,000 over 1925 exports and $15,000,000 over those of 1924, according to preliminary figures announced by the electrical equipment division of the Department of Commerce. The 1925 average monthly increase amounted to about $676,900 over 1925 and $1,259,000 over 1924. Out of a total of 67 classifications of exports, 44 showed an increase.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

American Blower Air Filter

IN THE air filter now being placed on the market by the American Blower Co., Detroit, Mich. and shown in Fig. 1, the design utilizes three factors for removing dust from air. These are: (1) centrifugal action, by reversal of air flow, (2) dry, hair-like tentacles for arresting and retaining dust particles and (3) cohesion of dust. As shown in Fig. 1, the filter is a

FIG. 1. VARIOUS COMBINATIONS OF FILTER CELLS CAN BE MADE TO SUIT CONDITIONS

combination of cells held in a frame, each cell being 18 in. high and 16 in. wide; this rectangular shape makes possible a great number of combinations of cells to suit the amount of air to be filtered and the installation space available for the unit. This filter is of the dry type, no oil or other adhesive being used to catch dust particles.

Figure 2 shows how the individual cells are made up and how the air passes through them. Each cell is composed of 10 or more perforated aluminum plates, each plate having a fireproof filament laid over it; the ferrule formed on the plate by the punching of the holes is turned back over this filament to hold it in place and form an aperture. The plate edges are flanged to strengthen the plate and form a spacer and the plates are loaded into a reinforced aluminum cell frame. Each cell is designed to handle 200 cu. ft. of air a minute at a frictional resistance of 0.375 in. of water.

Entering dust laden air is divided into jets in passing through the perforations of the first plate and as these jets strike the flat filament-coated surface of the second plate, dust is retained by the filament, while the air changes its direction and flows parallel to the plate surfaces to the staggered holes in the second plate and so on through the 10 plates of the cell.

As dust builds up on the flat surfaces, each layer

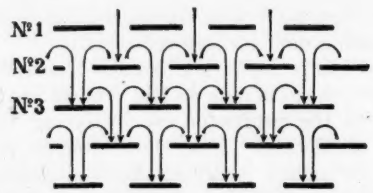


FIG. 2. HOLES ARE STAGGERED, THE DESIGN PROVIDING FOR FREE AIR PASSAGE AS DUST ACCUMULATES ON PLATES

of dust acts as a dust retaining member, obviating the use of oil or other adhesives. The cell is designed to cause the air flow to be constant regardless of the amount of dust collected, to make the dust elimination constant and to purify the air in a constantly decreasing rate. With 10 plates, the last plate collects about one per cent by weight of the total dust, as compared to that collected by the first plate.

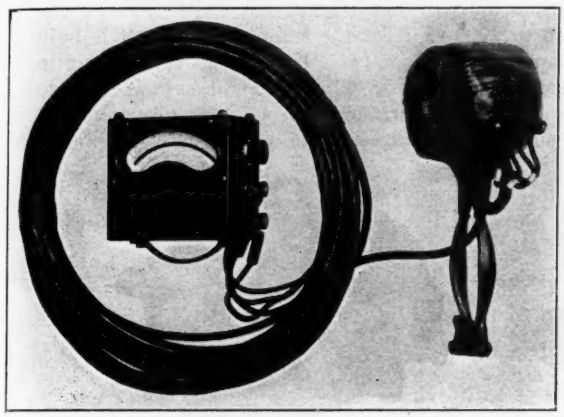
Although these filters are designed to retain as much as 2 to 2½ lb. of dirt without decreasing their effectiveness and to operate from 8 to 10 mo. without attention, it is recommended that they be unloaded once in six months. Unloading is by two methods: hand rapping of the plates for the moderate sized units and mechanical rapping for the larger filters with many cells.

Each cell weighs 4½ lb. and units can be supplied up to 5 cells wide and in varying heights, various combinations of cells and filter units being used according to conditions.

Pliers Type Current Measuring Set

DESIGNED FOR USE in determining the alternating current flowing in a conductor without opening the conductor to insert an ammeter or a current transformer to operate the ammeter, the new split-current measuring set recently developed by the General Electric Co. should prove of especial value in determining the load on feeders or distribution net works. Each set consists of a transformer with a hinged magnetic circuit, leads, and one or more ammeters. It can be used to advantage when it is not required that the accuracy be of the order than can be obtained only with self-contained ammeters or portable current transformers and ammeters.

A distinctive feature of the set is the ease with which the transformer can be clamped about the conductor. As may be seen from the accompanying illustration, it can be used as a pair of pliers with one hand, thus insuring safety for the lineman. In the case of overhead lines, the transformer can be clamped from below, thus avoiding the necessity of reaching over high voltage lines. Flexible multi-conductor leads 50 ft. in length are supplied with each set.



SPLIT CORE CURRENT MEASURING SET

Two sizes of transformers are supplied, one having a window opening of 1¼ in. and the other 2¼ in. in diameter. The former is rated 75, 125, 250 amp. primary. 2.5 amp. secondary when used with a single indicating ammeter. This transformer is also supplied with two indicating ammeters, one having a 2½-amp. winding, the other a 5-amp. winding.

A small sized indicating ammeter is furnished. It has a cylindrical switch by means of which the various ratings of the set can be readily obtained without the necessity of changing connections at either the transformer or the ammeter. Each indicating instrument is calibrated with the transformer with which it is to be used so the scale reads directly in primary amp. The recording instrument listed as standard with the test is Type CRP-4, a portable round pattern instrument with an 8-in. diameter chart and a one-day clock. The chart normally furnished makes one revolution in 24 hr., but other chart speeds, such as one revolution in 1, 6 or 12 hr. can be furnished.

Westinghouse Develops Single Retort Stoker

TO MEET the increasing demand for a single-retort stoker for industrial, central station and marine application and to develop a suitable grate mechanism to handle efficiently all bituminous coals, The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has brought out a unit known as the Westinghouse Single Retort Underfeed stoker, shown in the accompanying illustrations.

This stoker is applicable to small and medium sized boilers and where space is limited in connection with an existing boiler installation. The stoker can be driven either by an electric motor through a gear box or by a steam engine directly connected to the coal ram. To compensate for fluctuating loads, the drives are designed to give a wide range of speed.

The stoker grate is designed so that with each stroke of the coal ram, a rocking motion is given to the grate section resting on the central support known as the rocker sector. The rocking of this grate section imparts an undulating motion to the entire grate mechanism, the motion of which is intended to keep the fuel bed broken up and in a porous condition.

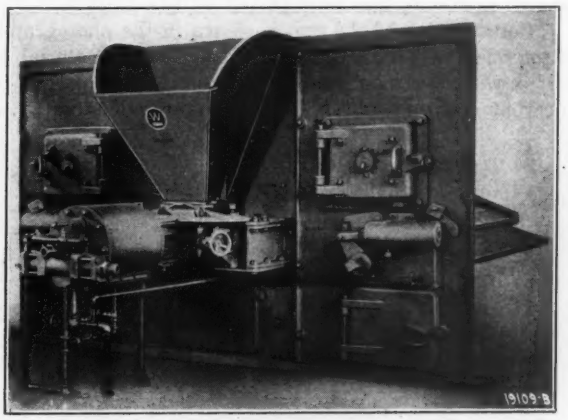


FIG. 1. FRONT OF NEW SINGLE RETORT UNDERFEED STOKER

Controls located at the front of the stoker govern the wave-like motion of the grate independent of the main coal ram and the movement of either half of the grate can be controlled independent of the other half. The grates are designed to admit and distribute air in the proper proportion to the various parts of the fuel bed; the total air admitting area is such as to secure efficient combustion with a minimum of static pressure.

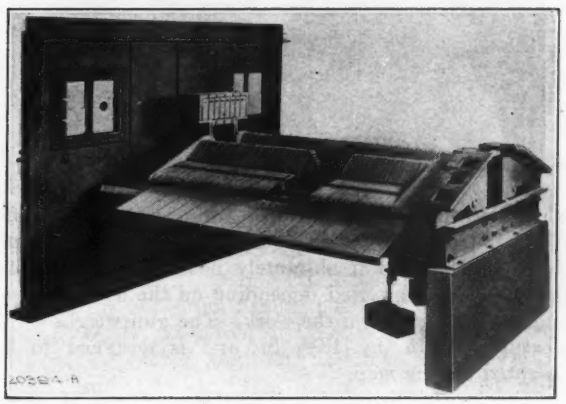


FIG. 2. GRATE IS GIVEN UNDULATING MOTION TO KEEP FUEL BED BROKEN UP

To minimize the work required in cleaning fires and also to save time, each dump grate is provided with an actuating mechanism to be operated by steam. Access to the stoker wind box and ash pits is made through doorways located in the stoker front. To take care of expansion and growth of the grate links, an automatic compensating device is provided.

Adamant Gun for Applying Refractory

FOR FACING OR COATING the fire-exposed surfaces of new or old furnace linings with Adamant fire brick cement, pre-mixed with Adachrome or other refractory materials and for filling in depressions or burned-out sections of brickwork, the Adamant Gun, shown herewith, has been placed on the market.

Construction of the gun is shown in the photograph. A nozzle specially designed to handle the material is fitted with a wooden handle, a supply pipe vented to prevent clogging and a ½-in. standard globe valve to

RIGHT—ADAMANT GUN DESIGNED TO APPLY MIXTURES OF PLASTIC REFRACTORY MATERIAL

BELOW—GUN IS DESIGNED FOR USE BY ONE MAN BY CONNECTING THE AIR LINE, PUTTING SUPPLY PIPE IN PRE-MIXTURE AND TURNING ON AIR WITH REGULATORY WHEEL

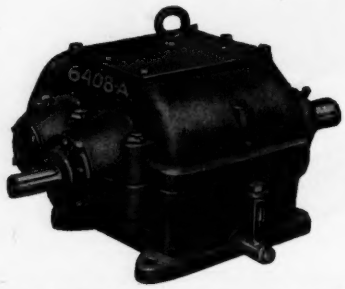
which is connected an air line for operating the gun. Air at 50 to 80 lb. pressure is recommended, although steam can be used if absolutely necessary. The above pressure may be varied depending on the mixture used and the distance from the work. The gun weighs 4 lb., measures 10 in. by 18½ in. and is designed to be operated by one man.

The larger illustration shows the method of using the Adamant Gun. The manufacturer, Botfield Refractories Co., Swanson and Clymer Sts., Philadelphia, Pa., states that it should be used at about 4 to 6 ft. from the work and that 100 lb. of pre-mixture should surface an area of 100 sq. ft. with a coating about ⅛ in. thick. For use with the gun, the company has developed Adachrome, a chemically neutral material, which is mixed with the proper proportion of Adamant Cement as a binder.

TO MEET requirements of heavy current welding, the Lincoln Electric Co. is developing several new accessories, one recently placed on the market being an electrode holder, for sizes up to ½-in. diameter and to carry 600 amp., with replaceable copper jaws.

New S-A. Gear Division Brings Out Speeducer

IN THE ACCOMPANYING illustration is shown the Speeducer, a speed reducer recently developed by the gear division of the Stephens-Adamson Mfg. Co., Aurora, Ill. This reducer consists of spur gears fully enclosed in an oil-tight housing, built in ratios varying up to 2000 to 1 for the standard sizes. It is built for capacities ranging from 1 hp. to 300 hp. Mounting of gears and shaft in a single rigid case is intended to secure proper alinement, in addition to eliminating the usual open gear hazard and the expense of gear guards.



SPEEDUCER IS SUPPLIED FOR RATIOS UP TO 2000 TO 1

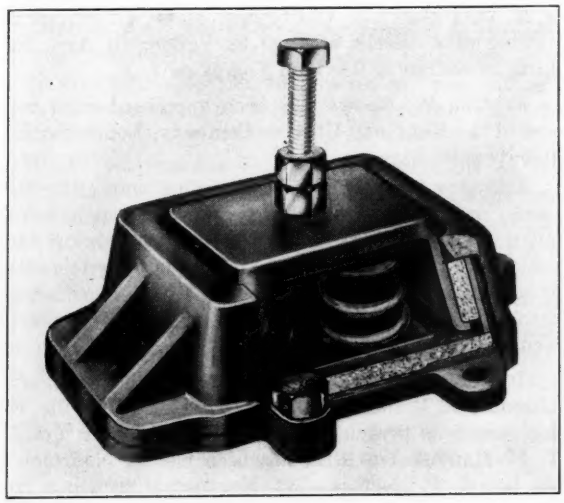
All gears in the Speeducer operate in a bath of oil. This unit is one of the latest products of the Gear Division of Stephens-Adamson Mfg. Co., which has recently been organized to produce all types of cast and cut tooth gears on a quantity basis. In addition to the Speeducer a complete line of speed reducers is offered including many spur and worm gear types. All this equipment is fully described in catalog No. 27 which can be obtained from the manufacturer.

Vibro-Damper Designed to Deaden Machine Vibrations

VIBRATIONS of all types of machinery, with the resulting noise and wear, have long been recognized as a serious problem by designers of machinery and buildings. To eliminate such vibration, the Vibro-Damper shown in the accompanying illustration has been developed by The Korfund Co., Inc., New York, manufacturer of Korfund cork foundation material.

The Vibro-Damper consists essentially of one or more springs enclosed in a spring casing, which is in turn surrounded by an outer housing firmly bolted to the base plate. The springs bear on a slab of vibration isolating material on the base plate and the spring casing is also separated from the housing by isolating material, this material being adjustable in the larger dampers. Tension of the springs can be adjusted by the same bolt which holds the machine base to the spring casing. The conical design of casing and housing is intended to prevent misalinement.

To install the dampers they are bolted to the machine base, then the machine and dampers are leveled on the foundation with shims and grouted in the usual way. The damper is designed to support the machine with springs fully released, but the tension can be easily increased with the holding bolt if necessary.



SPRINGS AND SPRING CASING ARE ISOLATED FROM BASE AND OUTER HOUSING

These Vibro-Dampers are made in five sizes to sustain loads from 40 lb. to 4000 lb. They are designed to be used for all machines except those having large acceleration forces or high kinetic energy, in which case Korfund foundation is recommended.

University of Iowa Builds New Power Plant

CONSTRUCTION WORK on the new power plant at the University of Iowa is progressing steadily and the major portion of the equipment is already installed. Four 612-hp. Stirling boilers, fired by Combustion Engineering Corp. natural draft chain grate stokers, designed to maintain 150 per cent rating on Iowa coal, will supply steam at 175 lb. gage, 100 deg. superheat. All four boilers will be served by a single concrete stack 205 ft. high above the floor and measuring 9 ft. 6 in. diameter at the top. Observation doors have been located at several points so that data regarding stack conditions at various points can be obtained.

Electric current will be generated by two water wheels and by two 1000-kw. Westinghouse bleeder turbines, the latter set over Worthington surface condensers. Steam for heating will be carried 1600 ft. back to the old power plant and old university buildings in one direction and 2000 ft. in the opposite direction for heating the new field house, new medical college and new hospital.

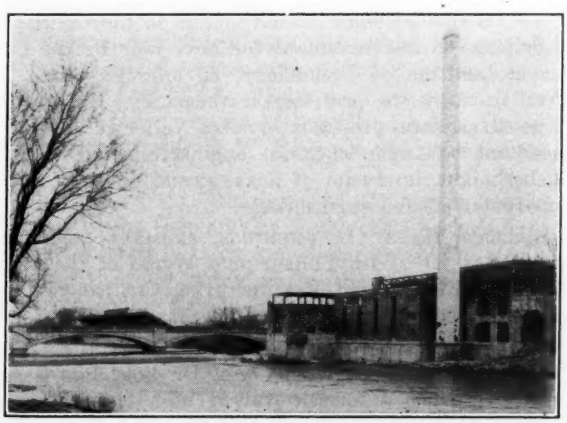


FIG. 1. STEAM FOR HEATING IS CARRIED UNDER THE RIVER THROUGH THE HOLLOW DAM SHOWN ABOVE

Design and engineering was handled by B. P. Fleming, Professor of Mechanical Engineering, who is also supervising the construction. The university owns the dam and water power rights which will be utilized to make a combination steam and hydro station. A number of interesting features have been incorporated including under-water coal storage, water reservoir under the boiler room, single coal and ash handling methods and provision for expansion of the boiler room two directions.

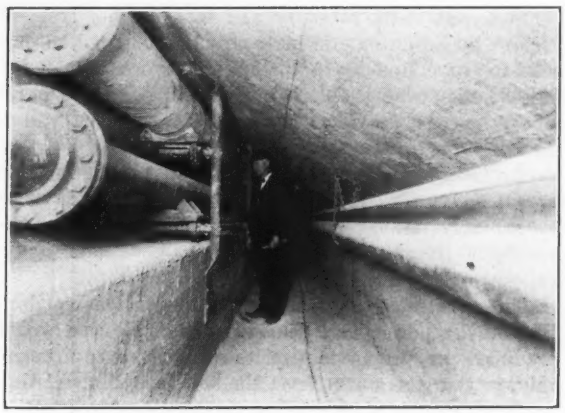


FIG. 2. VIEW OF THE INTERIOR OF THE DAM WITH 30 IN. OF WATER GOING OVER THE TOP

One of the most unusual features is the method of taking the steam lines under the river through the hollow dam. Two 8-in. steam lines, a 6-in. return and an electric conduit are provided. Except for the few lengths in the dam the steam lines are welded the entire distance.

New Features on Coupling

IMPROVED LUBRICATION features are announced on the Nicholson flexible coupling by the manufacturer, W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa. This coupling, described in the Dec. 15, 1926 issue of Power Plant Engineering, consists of two hubs connected by loose fitting, floating keys with beveled sides. The latest improvement consists in drilling holes longitudinally through the floating keys and hubs; these holes act as oil reservoirs. In addition, a lip is now extended from the casing over one of the hubs so that oil can be squirted under this lip when the coupling is either in motion or stationary. This lip together with the holes add space enough to increase the oil capacity of the coupling by 150 per cent. The arrangement is designed to keep the working parts flooded at all time and to maintain a perfect oil film and oil cushioning effect between all moving parts.

The new type coupling with oil lip will be known as Style A, while the old type without the oil lip will be known as Style B. The new type is fully described in Bulletin 627, just issued by the manufacturer.

By-Product Power for Packard

COAL SAVINGS amounting to at least 12,000 t. a year are expected by the Packard Motor Car Co. as a result of the installation, soon to be made, of a new heating system and an improved power plant. A new coal-fired boiler will be installed and a system for burning wood refuse is planned. The boiler will be a 3000-b.hp. unit, delivering steam at 325 lb. pressure to a 7500-kv.a., 6000-kw., 3600-r.p.m., 4600-v., 3-phase, 60-cycle turbine generator with a direct-connected exciter. The turbine generator will be a General Electric machine, the turbine being of mixed pressure type and direct connected to the generator.

Steam at 85-lb. pressure will be extracted from the turbine by an automatic internal valve and led through a 24-in. pipe line for a distance of more than a half mile to the forge shop, thereby eliminating a separate power house. Steam at atmospheric pressure will be used for the forced hot water heating system.

An interesting feature of the turbine is the fact that it will operate at a variable vacuum, ranging from approximately atmospheric pressure down to approximately 20 in. of vacuum, depending upon the steam requirements for hot water heating purposes.

The greatest economies are expected in the combination of the power and heating plants. Power will be produced in proportion to the heating requirements only, so that the steam from the boilers will at all times be doing double duty. Heating temperatures will be regulated at the power house.

The wood refuse system is an added feature to the operation of the power plant. All wood pieces, shavings and sawdust will be collected from the entire plant and blown to the power house through a 24-in. pipe line. There it will be hogged and delivered to two additional 500-hp., wood-burning boilers.

News Notes

KIELEY & MUELLER, INC., 34 W. 13th St., New York, N. Y., has appointed the Ray Engineering Co., Boston, Mass., as its Massachusetts agents.

PAUL D. CRAVATH, for 30 yr. general counsel, was elected temporary chairman of the board of directors of the Westinghouse Electric & Mfg. Co. at a meeting of directors held July 6 in New York City. The board adopted a resolution instructing the executive committee to nominate a permanent chairman. It was stated, on behalf of the committee, that they had no one at present in view for this office. The only addition made to the board of directors was the selection of W. L. Mellon of Pittsburgh.

BRIDGEPORT BRASS CO., Bridgeport, Conn., announces the appointment of Mr. William S. Kriebel, Jr., of Philadelphia, as salesman for its products in Philadelphia territory, with headquarters in the Bankers Trust Bldg., Philadelphia, Pa.

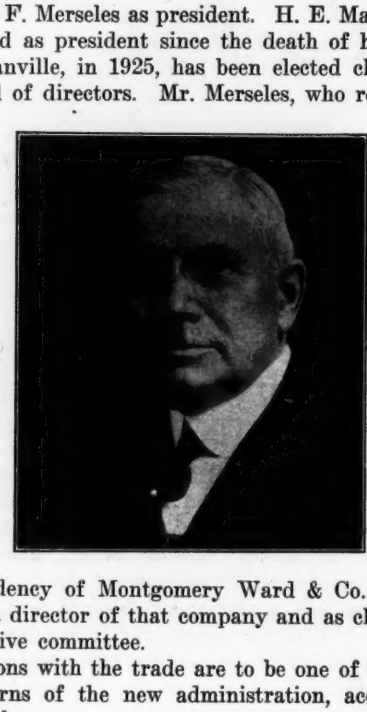
OKLAHOMA GAS & ELECTRIC CO. plans to increase the capacity of Harrah Station near Oklahoma City to a total of 80,400 hp. by the installation of an additional 33,500-hp. unit, according to a recent announcement by H. M. Byllesby & Co.

R. H. BAKER CO., Cambridge, Mass., announces the opening of a district office at 52 Vanderbilt Ave., New York, in charge of Rowland Tompkins.

EDWARD W. BROWN has been appointed chief engineer of the Kentucky Utilities Company, Louisville, Ky., and its subsidiaries.

THE NEW 33,000-V. transmission line connecting Somerset, Burnside, Waynesburg and other neighboring towns with Stanford, Kentucky, and supplying these towns with power from the Dix Dam hydroelectric plant, is now in service and the power plant at Somerset has been put in reserve, according to a recent statement by Kentucky Utilities News.

JOHNS-MANVILLE CORP. announces the election of Theodore F. Merseles as president. H. E. Manville, who has served as president since the death of his brother, T. F. Manville, in 1925, has been elected chairman of the board of directors. Mr. Merseles, who retires from



the presidency of Montgomery Ward & Co., will continue as a director of that company and as chairman of its executive committee.

Relations with the trade are to be one of the principal concerns of the new administration, according to Mr. Merseles.

MCCLAVE-BROOKS CO., Scranton, Pa., has appointed The Moss Engineering Co., 64 Wellington St., West, Empire Bldg., Toronto, Canada, as its representative for the sale of McClave combustion systems in Canada.

FIVE NEW FACULTY APPOINTMENTS to the College of Engineering are announced for next year by the Carnegie Institute of Technology, as follows: John H. Neelley, associate professor mathematics; Howard V. Russell, assistant professor physics; Walter H. J. Taylor, assistant professor chemical engineering; Charles E. Leberknight, instructor of physics; and John A. Davis, instructor of civil engineering.

MAJOR HENRY L. JENNINGS, assistant patent attorney at the South Philadelphia Works of the Westinghouse Electric and Manufacturing Co., has resigned his position to enter the practice of patent law with R. D. Johnston at Birmingham, Ala.

VULCAN SOOT CLEANER CO. of Du Bois, Pa., is now manufacturing automatic valved soot blowers under license from the patentees, the Diamond Power Specialty Co.

ARTHUR WEST has resigned his position as manager of power, engineering and sales for the Bethlehem Steel Co. to give more attention to personal business, but will retain a connection as consulting engineer with the company.

W. F. GRAVER has been elected president of the Graver Corp. of E. Chicago, Ind., succeeding his brother, J. P. Graver, who remains as vice president. W. F. Graver has been treasurer and vice president for a number of years, and will continue to serve as treasurer. Other changes in the organization are the election of K. W. Bartlett, for several years general manager, as vice president, and the appointment of A. E. Lucius, who has been legal representative of the company for several years, as assistant secretary. P. S. Graver continues as vice president in charge of manufacture, and H. S. Graver retains the position of secretary.

FIRST STEEL AND POWER SHOW will be held Aug. 31 to Sept. 2 in the new Varsity Arena, Toronto, Canada. This exhibition is sponsored by the Montreal and Toronto Chapters of the American Society for Steel Treating; the Canada, Toronto and Hamilton Councils of the Universal Craftsmen's Council of Engineers; the Toronto, Hamilton and Dominion Executive of the Engineers' Mutual Benefit Fund, the Toronto Branch of the American Electroplaters' Society, the Montreal and District Engineers' Association, and the Canadian Section of the American Welding Society. The General Chairman of the exhibition is C. Bradshaw, 153 University Ave., Toronto, Conada.

THE WISCONSIN-MICHIGAN POWER CO., Madison, Wis., formerly known as the Peninsula Power Co., has perfected plans for a merger of fifteen electric light and power utilities operating in Wisconsin and northern Michigan and to represent about $16,000,000 in property valuation. A. K. Ellis, vice president and general manager of the new company, will continue to operate a branch at Appleton; another office will be maintained at Iron Mountain, Michigan.

W. W. GASSER, CHIEF ENGINEER for the Western Iowa Co., was re-elected president of the Sioux City branch of the National Association of Stationary Engineers at the annual meeting June 30. Other officers of the branch were elected as follows: P. A. Hofland, vice president; R. A. Heilman, recording secretary; C. H. Amos, corresponding secretary; A. L. Schultz, financial secretary; J. A. Coulsen, treasurer; W. H. Gorman, conductor and G. H. Barton, doorkeeper. Mr. Gasser and Frank Fellwick were named delegates to the national convention in Los Angeles, Aug. 22-26. Thirty members attended the meeting and heard reports of the Iowa-Illinois convention in Rock Island by J. W. Peterson, who attended the meeting.

DUKE POWER CO., Charlotte, N. C., has purchased properties of the General Gas & Electric Co., including a one-half interest in Lexington Water Power Co., covering primarily a new hydroelectric generating plant to be constructed on the Saluda River.

INGERSOLL-RAND CO., 11 Broadway, New York, has opened a branch office at 236 High St., Newark, N. J., in charge of F. K. Armstrong.

DAYTON-DOWD CO., Quincy, Ill., announces the appointment of James E. Gegan Co., 622 First St., Detroit, Michigan, as its representative in the Detroit district.

Books and Catalogs

THERMODYNAMICS, by J. E. Emswiler, Professor of Mechanical Engineering, University of Michigan; cloth, 6 by 9 in.; second edition; 295 pages, 124 illustrations; New York, $3.00 net.

In the second edition of this popular work, which was written for use as a text, Professor Emswiler has added new material to bring it up to date and to show applications of principles in the most recent types of heat engines, to present the changed viewpoint of the author as to the importance or unimportance of some of the material in the first edition and to improve the presentation in certain parts. Since the principles of thermodynamics do not change, however, there has been no need to revise materially the discussion given of them. Also, as a result of the many favorable comments on the arrangement of the text, the original plan has been retained of presenting at the beginning of each theoretical discussion a schematic diagram of the actual heat engines to be studied and of reserving the more formal treatment of the abstract phases of thermodynamics until the student has acquired to some extent an experience or background of his own.

The new material added in the second edition consists of articles on the representation of heat quantities on the temperature-entropy diagram; on vapor refrigeration; on the internal combustion engines and on the air-steam mixture. Principles of the multiple-effect evaporator are treated and of especial interest is the new chapter on the various means employed in the modern power plant for extending the range and efficiency of the Rankine cycle.

Problems are given at the end of each chapter and, while these would be sufficient for use in a college course, to be supplemented by others given by the instructor, they would hardly be sufficient for a reader studying the book alone. Nevertheless, we feel that Professor Emswiler has made an important contribution to present power plant literature and that his book will be of really practical use to every power plant engineer, whether designer or operator.

THE ESSENTIALS OF TRANSFORMER PRACTICE, by Emerson G. Reed; 2nd edition, 401 pages; size 6 by 9, cloth, $5.00; New York, 1927.

Since its first edition published in 1923, this book has been considerably enlarged, something like 50 per cent of new material having been added. It is a book devoted essentially to a discussion of the theory of the transformer, the problems of design and operation. Only those theories are treated which have a direct bearing on the design and operation of transformer equipment.

The book is written with the hope of interesting engineering students as well as designing and operating engineers and is based upon a series of lectures to the transformer section of the Electric Club of the Westinghouse Elec. & Mfg. Co. Much of this material was published in serial form in the Electric Journal.

A valuable addition to this second edition is the chapter on physical and chemical properties of insulating oils written almost entirely by Messrs. C. A. Styer and J. G. Ford of the research engineering department of the Westinghouse Elec. & Mfg. Co.

THE LEEDS & NORTHRUP CO., 4201 Stenton Ave., Philadelphia, Pa., in a new publication, bulletin No. 660, describes an automatic system of metered combustion control for boiler furnaces. In this system an electric current controlled by steam pressure and flow in the steam main is used to supply metered quantities of air and fuel to each furnace in an exact and predetermined ratio and in measured response to station load demand. The bulletin explains the principles fully and gives complete details of the equipment and results obtained with it.

BAILEY METER CO., E. 46th and Euclid, Cleveland, Ohio, has just issued bulletin No. 43A, an illustrated eight-page booklet entitled, "Increase Boiler Efficiency by Using Bailey Meters," which includes records of installations in which large savings have been effected by the use of these meters.

BUFFALO FORGE CO., Buffalo, N. Y., in a well-illustrated 24-page bulletin, No. 422, describes Buffalo Conoidal ventilating fans in both duplex and turbo types.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., in catalog No. 45 describes Brown electric tachometers including a new form of centrifugal tachometer.

PLIBRICO JOINTLESS FIREBRICK CO., Kingsbury St., Chicago, is now publishing The Fire Box, a magazine for the man in charge of boilers and furnaces. This will contain editorial material of general interest as well as articles on refractories and it will be sent to any refractory user who applies for it, giving his business address and official title.

JEFFREY SAFELOAD FANS with full backward curved blades for power houses and general use where air is required against medium to high pressures are described in catalog No. 440 issued by the Jeffrey Mfg. Co., Columbus, Ohio.

THE MCCLAVE-BROOKS CO., Scranton, Pa., has recently issued a sixteen-page, well-illustrated bulletin describing its forced draft chain grate stoker for all grades of anthracite, coke breeze and mixtures. Another bulletin describes the type M-A anthracite stoker for the same fuels, while a third bulletin describes the McClave type 4-A anthracite dumping grate for small sizes of anthracite.

KENNEDY-VAN SAUN MFG. & ENG. CORP., 50 Church St., New York, in an illustrated 36-page bulletin, No. 12, discusses the application of powdered coal to steam boilers, cement kilns, dryers, metallurgical and chemical work and the results obtained with the air swept tube mill and carbureted fuel.

THE COCHRANE CORP., 17th St. and Allegheny Ave., Philadelphia, Pa., has just issued bulletin 674, describing the use of Cochrane special receiver separators as steam purifiers.

R. H. BEAUMONT CO., 319 Arch St., Philadelphia, Pa., in catalog 95, describes and illustrates the Beaumont Cable Drag Scraper System for stripping, loading, storing and reclaiming coal, sand, gravel stone and other bulk materials.

DEAN HILL PUMP CO., Anderson, Indiana, in bulletin No. 403, describes double suction centrifugal pumps, ball bearing type.

LEEDS & NORTHRUP CO., Philadelphia, Pa., in catalog 20, fully describes its various types of galvanometers.

THE NEW YORK BLOWER CO., 2248 S. Halsted St., Chicago, Ill., has just issued catalog 100 describing and illustrating the type M E fan for all power plant and industrial services.

LINK-BELT TYPICAL ELEVATORS are described in book No. 680 issued by Link-Belt Co., Chicago, Ill.

THE ENGINEER CO., 17 Battery Place, New York, in bulletins CTB 127 and ECB 227 describes installations of Enco cross baffles and Turner baffle walls for various types of vertical and horizontal water-tube boilers.

MCLEOD & HENRY CO., Troy, N. Y., has just issued a catalog describing and illustrating Steel Mixture Veneer Walls designed to meet the requirements of modern power plant furnaces with various types of boilers.

GENERAL ELECTRIC CO., Schenectady, N. Y., describes Station Oil Circuit Breakers for 15,000 to 88,000 v. in bulletin GEA-101A, just issued. In GEA-706, station oil circuit breakers for 15,000 and 25,000-v. service are discussed. Selsyns for distant signaling control and indication are described in bulletin GEA-722. In GEA-763 many data are given on induction motor panels, isolated type, for 2000 to 22,000 v. for motors with wound or squirrel-cage rotors. In Bulletin GEA-767 complete electric equipment for country grain elevators is described, including the new totally enclosed fan-cooled grain elevator motor.

WEBSTER FEED-WATER HEATERS of Genuine Puddled Wrought Iron are described in bulletin No. 103 issued by Warren Webster and Co., Camden, N. J.

INGERSOLL-RAND CO., in a new bulletin, describes its Little Tugger hoist and shows applications for hoisting, hauling and loading, in models for steam or compressed air operation, one direction or reversing.

ENGINEERING FOUNDATION, 29 W. 39th St., New York City, has issued publication No. 13 entitled "Manual of the Endurance of Metals under Repeated Stress," by H. F. Moore, research professor of engineering materials, University of Illinois. This is a summary of views and test data on this subject with instructions for use compiled for designing, inspecting and testing engineers.

NEW TYPE RW DISCONNECTING switches designed for 200, 400 and 600 amp., 7500 and 15,000 v., and 400 and 600 amp., 25,000, 37,000, 50,000 and 73,000 v. by the Westinghouse Electric and Manufacturing Company are described in Leaflet 20,318. Their general features and advantages are brought out in this discussion with the aid of halftone illustrations of different designs of switches, and diagrams of the various parts of the switches. Tables are also included in this leaflet giving over-all dimensions for the various types of RW switches and giving data on insulator flash-over valves.

CHICAGO water works history is summarized in a leaflet issued by the De Laval Steam Turbine Co., which shows over half of the present billion gallons daily supply is handled by De Laval centrifugal pumps and turbines. The progress made is shown by duty tests per 1000 lb. of steam at 175 lb. and 150 deg. superheat. For 1922, 154.36 million ft. lb.; for 1924, 172 million; for 1926 191.3 million and for the new 300-million gallon station, 203.5 million ft. lb. duty is guaranteed.